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# Implications of Using Computer-Based Training with the AN/SQQ-89(v) Sonar System: Operating and Support Costs

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Monterey, California. Naval Postgraduate School

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# NAVAL POSTGRADUATE SCHOOL

**MONTEREY, CALIFORNIA**

# THESIS

**IMPLICATIONS OF USING COMPUTER-BASED TRAINING ON THE AN/SQQ-89(V) SONAR SYSTEM: OPERATING AND SUPPORT COSTS**

by

William A. Gibson

June 2012

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| Thesis Co-Advisors: | Diana I. Angelis |
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The U.S. Navy transitioned to Computer-Based Training (CBT) in A and C schools in 2003 after a 2001 *Revolution in Training* report claimed that the Navy would realize savings in cost and training time without negatively affecting the quality of sailors arriving to the Fleet. This thesis analyzes Operating and Support (O&S) cost data for the AN/SQQ-89(v) sonar system to determine whether the transition to CBT contributed to increased Fleet maintenance costs. Determining how actions to change one aspect of a system affects other areas of the system will provide insight for future decisions affecting O&S cost, system life cycles, and Fleet material readiness.

The results of this thesis show that the conversion to CBT was not the sole contributing factor to increased Fleet maintenance costs or degraded Fleet material readiness. Changes to the Navy's training, maintenance, and manning programs during the early 2000s were all contributing factors.

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**IMPLICATIONS OF USING COMPUTER-BASED TRAINING WITH THE AN/SQQ-89(v) SONAR SYSTEM: OPERATING AND SUPPORT COSTS**

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN SYSTEMS ENGINEERING**

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 3-M | Maintenance and Material Management |
| 19 | AN/SQR-19 Towed Array Sonar |
| 28 | AN/SQQ-28 Sonar Signal Processing System |
| 53 | AN/SQS-53 Hull-Mounted Sonar |
| 56 | AN/SQS-56 Hull-Mounted Sonar |
| 89 | AN/SQQ-89(v) Sonar System |
| AIP | Awaiting Instruction Program |
| ANOVA | Analysis of Variance |
| AOA | Analysis of Alternatives |
| ASROC | Anti-Submarine Rocket |
| ASW | Anti-Submarine Warfare |
| AT/FP | Anti-Terrorism/Force Protection |
| ATG | Afloat Training Group |
| ATRC | AEGIS Training Readiness Center |
| BA | Billets Authorized |
| BA | Budget Authority (Appendix B) |
| CBT | Computer-based Training |
| CETS | Contractor Engineering and Technical Services |
| CG-47 | *Ticonderoga*-class cruiser |
| CMP | Class Maintenance Plan |
| CNE | Center for Naval Engineering |
| CNO | Chief of Naval Operations |
| COB | Current on Board |

| | |
|---|---|
| COTS | Commercial Off-the-Shelf |
| CSMP | Current Ship's Maintenance Project |
| DD-963 | *Spruance*-class destroyer |
| DDG-51 | *Arleigh Burke*-class destroyer |
| DoD | Department of Defense |
| DON | Department of the Navy |
| DSB | Defense Science Board |
| ECR | Electronic Classroom |
| ERNT | Executive Review of Navy Training |
| ETS | Engineering and Technical Services |
| EXCEL | Excellence through Commitment to Education and Learning |
| FCA | Fleet Concentration Area |
| FFG-7 | *Oliver Hazard Perry*-class frigate |
| FM | Fleet Modernization |
| FMPMIS | Fleet Modernization Program Management Information System |
| FRP | Fleet Review Panel |
| FY | Fiscal Year |
| GAO | Government Accounting Office |
| GMT | General Military Training |
| GOTS | Government Off-the-Shelf |
| GWOT | Global War on Terror |
| HPSM | Human Performance Systems Model |
| HPSO | Human Performance Systems Organization |
| HSI | Human Systems Integration |
| IA/GSA | Individual Augmentee/Global War on Terror Support Assignment |

| | |
|---|---|
| ICMP | Integrated Class Maintenance Plan |
| ICW | Interactive Courseware |
| IDTC | Inter-Deployment Training Cycle |
| IG | Inspector General |
| ILE | Integrated Learning Environment |
| ILT | Instructor-led Training |
| ILS | Integrated Logistics Support |
| IM | Intermediate Maintenance |
| IMA | Intermediate Maintenance Activity |
| IT | Information Systems Technician |
| JSN | Job Sequence Number |
| KSATs | Knowledge, Skills, Abilities, and Tools |
| LAMPS | Light Airborne Multi-Purpose System |
| LCM | Life Cycle Management |
| LMS | Learning Management System |
| LOGCEN | Logistics Center |
| LOK | Level of Knowledge |
| MI | Maintenance – Intermediate |
| MIP | Maintenance Index Page |
| MM | Maintenance – Modernization |
| NAVSEA | Naval Sea Systems Command |
| NEC | Navy Enlisted Classification |
| NEL | Navy E-Learning |
| NETPDTC | Naval Education and Training Professional Development and Technology Center |

| | |
|---|---|
| NETS | Navy Engineering and Technical Services |
| NM | Nautical Mile |
| NMP | Navy Manning Plan |
| NPC | Naval Personnel Command |
| NTSP | Navy Training Systems Plan |
| PC | Personal Computer |
| PEO IWS | Program Executive Office Integrated Warfare Systems |
| O&I | Organizational and Intermediate |
| O-level | Organizational Level |
| OJT | On-the-Job Training |
| O&M | Operations and Maintenance |
| OPTEMPO | Operational Tempo |
| O&S | Operating and Support |
| OOB | Order of Battle |
| PMS | Planned Maintenance System |
| ROC/POE | Required Operational Capabilities and Projected Operational Environment |
| ROI | Return on Investment |
| RMC | Regional Maintenance Center |
| RSO | Regional Support Organization |
| SIMA | Shore Intermediate Maintenance Activity |
| SIMAS | Sonar In-Situ Mode Assessment System |
| SIPRNET | Secret Internet Protocol Router Network |
| SME | Subject Matter Expert |
| SRF | Ship Repair Facility |
| STG | Sonar Technician - Surface |

| | |
|---|---|
| SUPSHIP | Supervisor of Shipbuilding |
| SWOS | Surface Warfare Officer School |
| SYMIS | Ship Yard Management Information System |
| TACTAS | Tactical Towed Array Sonar |
| TAP | Transition Assistance Program |
| TMA | Target Motion Analysis |
| TOA | Total Obligation Authority |
| UFCS | Underwater Fire Control System |
| ULC | Unit Level Consumption |
| US | United States |
| U/W | Underway |
| VAK | Visual, Auditory, Kinesthetic |
| VAMOSC | Visibility and Management of Operating and Support Costs |
| VMA | Variant Manning Average |
| WAP | Weapons Alternate Processor |
| WCS | Work Center Supervisor |
| XBT | Expendable Bathythermograph |

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# EXECUTIVE SUMMARY

Changes to the U.S. Navy's training, maintenance, and manning policies in the late 1990s and early 2000s resulted in degraded Fleet material readiness. One of the changes was the transition from Instructor Led Training (ILT) to Computer Based Training (CBT) in A and C schools in 2003. The US Navy expected significant cost savings as a result of this change without any degradation in the level of knowledge and skills produced by the training. This thesis examines the transition to CBT from a systems perspective to determine if it may have contributed to a loss of readiness and an increase in total system life cycle costs. The thesis looks at several questions. First, did the use of CBT in A and C schools result in sailors entering the fleet with lower levels of knowledge and skill sets than those sailors completing ILT? Second, did the transition to CBT result in cost savings in training? And finally, from a systems perspective, if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased operations and maintenance (O&M) costs?

To answer the first question, government studies of the Navy's CBT training were examined, which confirmed that while the transition to CBT resulted in shorter training times, sailors reporting to the Fleet were not as well prepared as ILT-trained sailors of the past. To answer the second question, DON Budget Reports from FYs 2000 to 2012 were analyzed to understand changes in training costs during the periods before and after the implementation of CBT. The analysis reveals that overall training costs remained fairly flat and specialized skills training costs nearly doubled over the same period, which suggests that any cost savings were realized in areas other than training delivery in A and C schools.

To answer the final question, the thesis examines changes to training and maintenance costs from both a macro and micro perspective. At the macro level, analysis of DON O&M budgets for the periods before and after CBT implementation shows that Intermediate Maintenance budgets more than doubled and Depot Level Maintenance budgets nearly doubled during the period of interest. Unfortunately there were too many confounding variables that could have affected O&M costs during this period of time to

draw any conclusions about the effect of training on maintenance costs. To control some of these variables it is necessary to examine the question at a micro level.

This thesis focused on the AN/SQQ-89(v) sonar system to understand how the conversion to CBT affected one system in particular. Reports on the Navy's changes in training, maintenance, and manning were examined in detail to understand what changes were made and what the effects of those changes were on training, readiness, and cost. Additionally, Operating and Support (O&S) cost data and 89 system data were analyzed to determine whether the conversion to CBT had a direct impact on rising maintenance costs for the system. Data analysis revealed that there was not a direct correlation between the conversion to CBT and increased maintenance costs for the AN/SQQ-89(v) sonar system. While training costs decreased and maintenance costs rose in the 2000s, the events were not directly related. It is more likely that massive systemic changes in training, maintenance, and manning caused unintended second- and third-order effects that collectively contributed to degraded Fleet material readiness.

For instance, the way that CBT was implemented in Navy A and C schools produced sailors that were ill-equipped to perform basic rate-related tasks. At the same time, the removal of instructors from the schoolhouse who were subject-matter experts (SMEs) in the course they were teaching exacerbated the problem. Additionally, SME instructors would typically return to the fleet after their teaching tour and provide valuable experience to their next ship. Since instructors were removed from the schoolhouse, this important shipboard training resource was eliminated. Since Fleet manning was reduced, there are fewer sailors available to perform shipboard requirements. Since sailors are not as technically competent as their predecessors, and there are fewer sailors available, material readiness suffers. At the same time, the elimination of enlisted shore billets and Shore Intermediate Maintenance Activities (SIMAs) caused degradation in sailors' technical competence and created a backlog of jobs, further degrading Fleet material readiness.

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# I. INTRODUCTION

## A. BACKGROUND

As the United States Navy entered the new millennium, Navy leadership expressed concern that the training programs in place would not adequately meet future training demands (Executive Review of Navy Training (ERNT), 2001). The Defense Science Board (DSB) Task Force stated:

> Future training must be delivered to the individual, to units, and to joint forces, when it is needed, not in the schoolhouse after which there is time for proficiency to decay. Training must be applied over and over again as the composition of the units and joint forces changes and as skills erode over time. Training must also become an integral part of the acquisition of hardware or we will fail to achieve the performance in our weapons systems that our other superiority (technology) strives to deliver (Chatham & Braddock, 2000, p. 3).

At the time, rate training (specialized skills training) in 'A' and 'C' schools was primarily conducted through formal "schoolhouse" training, i.e., training that took place in a traditional classroom with an instructor present. In their 2000 *Training Superiority & Training Surprise* report, the DSB Task Force reported that once a skill is learned, proficiency in that skill can be forgotten if not used and exercised frequently (Chatham & Braddock, 2000). The skills taught in 'A' and 'C' skills can suffer from "learning decay" by the time sailors reach the fleet and can decay further if not reinforced by refresher training. The DSB Task Force called for a "second revolution in training" that would deliver training "to the individual, to units, and to joint forces (Chatham & Braddock, 2000)." As a result, the Chief of Naval Operations (CNO) chartered an Executive Review of Navy Training (ERNT) to review the Navy training system and recommend solutions to improve training effectiveness and meet future training demands (ERNT, 2001).

In 2001, ERNT released *Revolution in Training: Executive Review of Navy Training Final Report* (ERNT, 2001). According to the report, training activities comprised 14% of the overall US Navy budget. Additionally, formal schoolhouse training represents a large monetary investment due to the need for facilities, instructors, and laboratories, in addition to student costs. Furthermore, the report stated that future training demands would outstrip the number of billets available under the legacy schoolhouse system, and the suggestion was made that the use of technologies and modern training methods would contribute to a training cost reduction without producing a reduction in the quality of sailor produced by the training.

As a result of the 2001 report, the U.S. Navy implemented a new training strategy that used several of the report's suggestions. Task Force EXCEL (Excellence through Commitment to Education and Learning) was established under the leadership of the CNO, Admiral Vern Clark. The goals of Task Force EXCEL were to establish a continuum of lifelong learning, use a streamlined funding process and a single training authority, create a Human Performance Systems Model (HPSM), and to link training and acquisition (Naval Personnel Development Command, 2002).

Part of this new strategy included the addition of new training technologies such as distributed learning, CBT, collaborative learning, and computer-mediated learning. The Navy claimed that the introduction of CBT would reduce both training time and training costs without reducing the quality of training received (ERNT, 2001).

## B. SCOPE

This thesis looks to answer several questions. First, did the use of CBT in A and C schools result in sailors entering the fleet with lower levels of knowledge and skill sets than those sailors completing ILS? Second, did the transition to CBT result in cost savings in training? And finally, from a systems perspective, if sailors trained with CBT had lower knowledge and skill levels, did the conversion to CBT contribute to increased operations and maintenance costs?

A 2009 Naval Inspector General (IG) Report, *Computer Based Training*, reported that the introduction of CBT did reduce training time. However, sailors arriving to the fleet under CBT did not usually meet the required Knowledge, Skills, Abilities, and Tools (KSATs) upon reporting on board. Because of this, ships had to take the time to train sailors up to acceptable standards (Naval Inspector General, 2009). The analysis of Department of the Navy (DON) Budget Reports conducted as part of this thesis research shows that the amount of money spent on training remained relatively consistent from

FYs 2000 through 2010. This suggests that the transition to CBT has not produced the desired reduction in costs. Furthermore, analysis of the DON O&M budgets the periods before and after CBT implementation shows that Intermediate Maintenance budgets more than doubled and Depot Level Maintenance budgets nearly doubled during the period of interest. This macro level analysis confirms that overall DON costs have increased, but does not provide enough granularity to answer the final question, namely, "if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased operations and maintenance costs?" A closer examination of a particular system (the system selected was the AN/SQQ-89(v) sonar) was the method used to answer this question.

In order to answer these research questions, this report starts with a discussion of the Navy's legacy training system, the Revolution in Training, and CBT. Next, the thesis discusses the Navy maintenance process, including Depot Level Maintenance, Intermediate Maintenance (IM), and the realignment of maintenance facilities during the 2000s. Finally, an examination of the DON budgets from FYs 2000 through 2010 is conducted, paying particular attention to training and maintenance figures.

At the macro level, there are many variables besides CBT that could contribute to rising maintenance costs, including the Global War on Terror (GWOT) and increased operations tempo (OPTEMPO). However, it is impractical to isolate the impact of CBT on Navy maintenance costs at the macro level. Instead, it is necessary to look at the impact of CBT on a particular system, program, or technology. This research effort focuses on a single system, the AN/SQQ-89(v) sonar, collecting data at a level of detail that allows for the control of the various variables that might impact maintenance costs. Thus, the scope of this thesis will include an examination of the AN/SQQ-89(v) sonar system to analyze how the conversion to CBT affected this system in particular.

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# II. TRAINING

The U.S. Navy was interested in examining changes in its training structure in the late 1990s and early 2000s. The results were a 2001 *Revolution in Training* report that made several recommendations to change the Navy training system. This chapter examines the *Revolution in Training* report and two follow-on reports, *Computer Based Training* and *Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training*, that reported on the impact of the changes to Navy training 10 years later.

## A. INTRODUCTION

Training in the Navy occurs throughout a sailor's career, beginning with recruit training and ultimately ending with the Transition Assistance Program (TAP), when a sailor separates or retires from service. In addition to these events, sailors can expect to go through several other training programs throughout their career. Upon completion of recruit training, sailors are sent to specialized skill training in their designated job specialty, or rating.

In-rate training begins in A school, where sailors learn the particular skills specific to their job. From there, a sailor can receive additional training in C school, as C schools provide specialized training in a particular aspect of a rating. For example, in the Sonar Technician—Surface (STG) rating, a sailor can earn the 0510 Navy Enlisted Classification (NEC), designating them as an AN/SQS-53D Sensor Subsystem Level II Technician/Operator (Navy Personnel Command, 2012). Once a sailor is assigned to a ship, he or she receives training for collateral duties such as quarterdeck watches, anti-terrorism/force protection (AT/FP) watches, weapons handling, and the at-sea fire party. Additionally, sailors can expect to receive general military training (GMT) in topics ranging from electrical safety to suicide prevention.

Prior to 2003, nearly all of this training was conducted using some form of ILT (ERNT, 2001). Portions of recruit training were conducted in a formal schoolhouse setting, and all in-rate training was conducted in this manner as well. GMT was conducted at command-level training “stand-downs,” a term which describes training occurring when designated personnel provide the GMT to the crew in a lecture format.

After the 2001 ERNT report and the establishment of Task Force EXCEL, the Navy introduced several electronic training initiatives aimed at revolutionizing the training process and placing less emphasis on ILT. This section will define ILT and CBT as they pertain to the Navy, further discuss the *Revolution in Training* report, and discuss the impacts of Task Force EXCEL’s initiatives by examining a 2009 Navy IG report, *Computer Based Training,* and a 2010 Government Accountability Office (GAO) report, *Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training*. Additionally, this report will focus solely on ILT and CBT as they pertain to the specialized skill training received in A and C schools, considering carefully the claims which suggest that CBT would offer significant cost and time savings without degrading training quality.

## B. INSTRUCTOR-LED TRAINING (ILT)

Until the early 2000s, in-rate training in the Navy was conducted in a formal schoolhouse setting, where instructors delivering the training are subject matter experts (SMEs) on the material they are teaching (ERNT, 2001). Typically, they come from the Fleet and have worked on the equipment they are teaching about. Information is delivered in the form of lectures and instructors are able to supplement the lecture material with tips and anecdotes from their career experiences (Naval Inspector General, 2009).

In addition to lectures, sailors are able to reinforce their comprehension of the lecture material through hands-on experience in a laboratory setting. In maintenance courses, students are able to work on the exact equipment they see in the Fleet and instructors are able to simulate equipment casualties for technicians to troubleshoot.

Instructors are able to tailor the delivery of material to a class based on the students’ level of comprehension. For example, if a class has difficulty understanding a particular concept, the instructor can choose to spend more time in the lab to reinforce what is learned during the classroom portion.

There are several benefits to ILT. Since a single instructor teaches a large group of students, group learning techniques can be employed that would otherwise be unavailable in one-on-one or CBT instruction. The formation of small groups within a class fosters team-building and allows students to help and teach each other. Compared to the costs of software development, testing, and hardware purchase, ILT is in some ways more cost-effective, depending on class size and length of use. Additionally, the controlled classroom environment offers fewer distractions than CBT or distance learning. Finally, ILT doesn't take as long to develop as CBT. It takes approximately 34 hours to develop one hour of ILT (Chapman, 2007), while it takes approximately 220 hours to develop a standard e-learning course (Chapman, 2006).

ILT also has its disadvantages. Since everyone has different learning capabilities, some students may be more advanced and become bored while waiting for slower learners to catch up. Conversely, slow learners may have difficulty keeping up. Depending on the size and duration of the course, ILT may be more expensive than CBT.

## C. COMPUTER-BASED TRAINING (CBT)

*Computer Based Training* defines CBT as "individual or group self-paced instruction using a computer as the primary training medium, to include web-delivered Navy E-Learning (NEL)" (Naval Inspector General, 2009, p. ii). Based on the recommendations of the *Revolution in Training Report*, the Navy established Task Force EXCEL and brought CBT into the schoolhouse at A and C schools. By the time of release of the 2009 Navy IG report, 34% of all A school training was delivered by CBT (Naval Inspector General, 2009).

In the CBT learning environment in A schools, students go through learning modules on a personal computer (PC). Since students are at their own work stations, the learning is self-paced. When a student is done processing the information presented on the screen, they click "next" to proceed to the next piece of information. There are usually small knowledge assessments throughout the module, followed by a final knowledge assessment at the end of the module (Naval Inspector General, 2009, p. 7).

Because the learning is self-paced, instructors were replaced with “facilitators.” Facilitators are not necessarily SMEs in the subject matter being delivered in the CBT modules. The purpose of the facilitator is “to ensure classroom rules are followed, assist with computer-related issues, and monitor student progress. They do not provide reinforcement of learning objectives or enhance retention of course material” (Naval Inspector General, 2009). The problem with replacing instructors with facilitators is that students cannot go to a facilitator with a question about subject material. It removes the opportunity to teach when a student is confused. Additionally, instructors provide an example of what an experienced sailor should be in terms of appearance, demeanor, and professionalism. This was lost in the switch to facilitators (Navy Inspector General, 2009).

There are several advantages to CBT. The learning is self-paced and if the course is offered as distance learning, the schedule to take the course is flexible. Students can complete the course at their own pace, which generally shortens training time. Since there are no instructors involved, the message doesn’t change from one person to the next (Dhanjal & Calis, 1999).

CBT also has disadvantages. Students don’t have the ability to talk to a SME if there is confusion about a topic. Since the schedule is flexible, procrastination can set in. Since the training is one-on-one, students don’t have the benefits provided by group instruction.

## D. REVOLUTION IN TRAINING: A KEY REPORT ON NAVY TRAINING

### 1. Background

In order to provide an adequate context for the data analysis conducted in subsequent chapters of this thesis, an intensive examination of a key document explaining training policy in the Navy is necessary. This section features a summary of crucial information provided by a CNO initiated study into how training is conducted in the U.S. Navy.

In October 2000, the CNO tasked the formation of a group to conduct a review of Navy training, i.e., the Executive Review of Navy Training group. The ERNT group was charged with providing insights on how to improve and align training organizations, leverage civilian training practices, and use new technologies to provide a continuum of training for sailors. The 24-member group was comprised of military and civilian personnel, members of academia, research institutions, and industry.

During their review, the group noted that the demands for training had increased. At the macro level, the training demands are driven by the set of Required Operational Capabilities and Projected Operating Environments (ROC/POE). ROC/POE is used to determine specific warfighting missions for each ship. Training requirements are derived from these missions and are then used to determine specific training requirements for sailors. Changes in the ROC/POE led to increased training requirements for units during Inter-Deployment Training Cycles (IDTCs). For example, IDTC requirements for an air squadron increased by 31% over an 8-year period. Ship training requirements are passed down to the sailor level, and in many cases, this resulted in billets which could not be filled because there were no sailors with the required training to fill them. In the Information Systems Technician (IT) rating for example, billet shortfalls ranged from 19–79% for certain NECs. At the same time, the pool of experienced sailors had decreased due to the 1990s drawdown and retirements from that group of remaining sailors, and the fact that it was difficult to compete with the civilian sector and a healthy U.S. economy. Many sailors were receiving training through the military and then leaving for jobs in the civilian sector.

The group reported that the Navy training system was not constructed to support the training demands based on increased ROC/POE requirements. The additional training requirements are tied to NECs and billets which require training in schoolhouses. Since there a finite number of seats available in the schoolhouses, demand outstrips the number of available seats. Because of this, there were gaps in what types of training (NECs) that current and/or potential sailors wanted and what could be delivered. The group suggested that technology and the science of learning offered several opportunities to improve the Navy training system by reducing training time through CBT and offering distributed learning opportunities that could be executed at the workplace. This is discussed further at the end of the report, (in the Conclusion/Recommendations section, II.D.6.)

### 2. Data

During their study, ERNT collected data reflecting the status of Navy training in 2000. They found that the US Navy training budget in 2000 was $10B, which accounted for 14% of total annual funding. Funding from the 2000 training budget went to more than 1,000 training sites. From these sites, more than 900,000 training opportunities were provided to approximately 460,000 active duty and reserve sailors (ERNT, 2001). But the study found flaws in the way training was funded. For example, training money came from 11 different resource sponsors and was then distributed to 12 training claimants who spent the money. This lack of organization is inefficient, since money being spread through so many areas causes some training areas to be redundantly funded, while others are neglected (ERNT, 2001).

In one part of the study, ERNT noted that e-learning reduced training costs by 30–60% while in another part of the study they noted that the use of technology saves the Navy 25–33%. ERNT claimed that e-learning reduced training time by 20–40% while increasing knowledge retention by 10–30%. The report cited a U.S. Army example that e-learning resulted in $155M in cost savings and a 30% reduction in training time when e-learning was implemented for 525 courses (ERNT, 2001). These contradicting numbers illustrate how difficult it is to truly capture how the use of technology impacts training. Additionally, they found that there was no central authority in the training system (ERNT, 2001). The lack of authority causes ships to be assessed in the same training areas multiple times by different organizations. The lack of coordination places additional stresses on ships with an already full operational schedule. For example, the tactical training organization was made of 38 different organizations that performed management functions, 39 that could coordinate exercises, and more than 60 schoolhouses (ERNT, 2001). They also discovered that there were 63 different organizations that could impose training requirements (ERNT, 2001).

### 3. Findings

In addition to the data gathered, ERNT made several observations about how the Navy training organization operated up to the point of the report (ERNT, 2001). The

Navy's problems with training began at the recruitment phase. Recruiters tried to get people into the Navy, but they weren't concerned with matching skills and interests to Navy billet requirements. Recruiting was more about meeting quotas than making sure the people were the right fit for the job they were assigned. Thus, recruiting practices weren't aligned with training. The Navy's recruiting philosophy thus contrasts negatively with modern industry, as modern industry views human resources and training as in integral part of their business strategy (ERNT, 2001). Modern industry places an emphasis on human performance and the science of learning. Human performance recognizes that how a human interacts with a piece of equipment is just as or more important than the sophistication of the equipment itself. While industry tends to value human performance, many military programs put more emphasis on the equipment without considering how the human will interact with it (ERNT, 2001). The science of learning focuses on how individuals learn and recognizes that each person learns at a different speed. Researchers recognized that classroom instruction in the military is geared towards the slowest learner because everyone must have grasp of the topic before proceeding to the next one (ERNT, 2001). Self-paced CBT allows each individual student to proceed at his or her own pace, speeding up the learning process for faster learners and allowing slower learners to take as much time as necessary to grasp a subject. Industry and civilian research have highlighted this concept, and this was recognized as a need for the Navy (ERNT, 2001).

In addition to the recruiting problem, there are several structural problems with the Navy training organization. There were too many commands and organizations with redundant training requirements and there was no coordination between the commands. For example, training funding was drawn from 11 different areas and distributed to 12 claimants, so there was no central way to manage funding. Since there was no central management for the funding or administration of training, multiple funding areas and claimants led to redundancies and gaps throughout the training organization. Some training organizations had overlapping interests, so some training areas were funded multiple times. At the same time, some training areas fell through the cracks because there was no oversight to tell whether that training area had been met or funded by one of the multiple training organizations.

Finally, it was discovered that human systems integration (HSI) did not receive enough consideration during acquisition, revealing that personnel were not properly regarded as important contributors to system performance. Human performance as an area of study encompasses not only equipment, but also the skills required to operate a particular system. If human performance is considered early, developers can determine what skills are required, how much training is required, how many operators are required, or if a system will require redevelopment. Often, since human performance was not considered early in the design process, the need for additional manning on ships arose. The money required to provide the additional manning typically came from training and Integrated Logistic Support (ILS) funds for the system (ERNT, 2001).

Reviews of the training program revealed that ILT was the primary training method used to deliver training. Interviews with sailors revealed that their best training experiences occurred when knowledgeable instructors delivered relevant content and provided hands-on training (ERNT), 2001). Upon reporting to a ship, sailors felt that they did not meet the level of knowledge requirements when reporting to their new commands and saw several obstacles to receiving additional training. These impediments included a lack of time to train, on-board personnel shortages, course availability, inadequate facilities or equipment, and a low priority level set by their command to receive additional training (ERNT, 2001).

In addition to the sailor's noted concerns, there has also been an increase in mission sets added to ships, i.e., there were an increase in the amount of training requirements assigned to sailors, but no additional sailors were added to the ship. A final concern is that throughout a ship's training cycle, training and knowledge retention atrophies through the course of a deployment due to learning decay (ERNT, 2001).

The additional requirements made it difficult for sailors to receive OJT. But a clear recommendation from the study was the need for and the undisputed quality of OJT: this is stated boldly by the research group:

> The Navy needs to provide explicit support for the conduct of on-the-job training. OJT is, by all accounts (including our interviews with Sailors), the most effective training that our Sailors experience. There is great potential to improve that training by focusing on it explicitly during the implementation of the recommendations of the Executive Review of Navy Training. (pp. 58–59.)

Unfortunately, it is difficult to determine what training tools were the best to use. This is best explained by a statement made earlier in their report which indicates that the above statement may not be as easy to implement as it might seem; as the report had observed in another place,

> Historical evidence says that if the training system does not send adequately trained Sailors to the Fleet, they will not 'catch up' in the Fleet —or in actual war fighting. In fact, operational performance is extremely sensitive to readiness levels at the onset of operations or combat. This is well documented (by early mission attrition data) from World War II, Korea, and Vietnam, and the lesson has been relearned in the recent Desert Fox and Noble Anvil operations. (ERNT, 2001, p. 6.)

The importance of adequate training is clear, because of the fact that without the necessary foundation, sailors can't make up for poor training with training occurring at a later date.

An additional training problem to consider has to do with the creation of training plans, as some particular systems have problems from the beginning because of a poor conception. For example, all systems are required to have Navy Training Systems Plans (NTSP), which is described here:

> An NTSP defines the training necessary to support the operation and maintenance of the system. The NTSP process, when properly executed, provides opportunities for the Fleet, resource sponsor, CNET, and personnel command to review and assess training requirements. (ERNT, 2001, p.10)

Unfortunately, many systems were installed on afloat units without NTSPs. This was attributed to the rapid fielding of systems using commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) technologies. COTS/GOTS systems were usually upgrades to existing systems and in many cases, NTSPs were never sent. This presents a challenge for training organizations because training material is either unavailable or out of date, depending on whether the system is new or updated. In both cases, training commands and fleet units have to play catch-up once a system is fielded without a NTSP.

#### 4. Observations

Some key points from the 2001 analysis of the state of Navy training were that 1) training may not continue to meet readiness requirements in the post-Cold War era given the decreased manning and increased requirements imposed upon ships and 2) due to a good job market in the civilian sector at the time (2000), it was possible that the Navy would be unable to recruit the right number of people with the proper skillsets.

The important recommendations from the ERNT for the purposes of this thesis research were that the Navy's training program should be realigned to meet the following objectives:

1) Sailors should be trained to maintain and operate systems at the highest levels of readiness and performance,

2) Training considerations should begin at equipment acquisition and continue through operation of the system until retirement,

3) Sailors must be equipped with the necessary skillsets to operate/maintain the equipment from cradle to grave, and

4) The objective of training is to achieve readiness and ensure mission accomplishment (ERNT, 2001)

A key point in considering CBT involves the question of how to conduct training with respect to new equipment. While the assumption has been that when a new piece of equipment was deployed, formal schoolhouse training was required, it has been suggested that that schoolhouse training was expensive and that training facilities represented a large investment over a long period of time. Because of the expense of training, and because as of 2000, the demand for billets in Navy schoolhouses exceeded the budgeted forecast, resulting in a shortfall of qualified sailors in the Fleet, it has been proposed that modern learning techniques such as CBT would reduce the need to send students to the schoolhouse (ERNT, 2001) One key topic for analyzing training is the use of performance measures in place to assess the effectiveness of training. The Navy did not have a method to assess whether training was valuable, in contrast to civilian industry, which was developing measurement criteria for training because, in their view, training was tied to earnings. One way to measure performance is the 1959 Kirkpatrick 4-level measurement model that is the industry standard. In a 2005 survey, 96% of companies interviewed used some elements or variation of the Kirkpatrick model (Bassi, Gallager, & Schroer, 1996). The Kirkpatrick model includes the following measures:

- *Reactions* – Studies students' answers to questions about the training they received.
- *Learning* – Measures whether the student retained the skills taught.
- *Behavior* – Measures whether the learner acquired the skills taught through a demonstration test.
- *Results* – Measures "whether or not the organization actually achieves its desired objectives as a function of training." (ERNT, 2001)

From these observations, the ERNT group developed a series of conclusions and recommendations to improve Navy training.

### 5. ERNT Report Conclusions and Recommendations

Intensive analysis of Navy training recommended a 4-step process to revolutionize Navy training: 1) Adopt a Navy Human Performance System Model (HPSM), 2) Align training, 3) Emphasize human performance in acquisition, and 4) Establish a lifelong learning continuum (ERNT, 2001). The next section of the thesis addresses each of these four steps.

#### *a. Adopt a Navy HPSM*

The Navy training system has not been not well organized. For example, there are several organizations with overlapping requirements and there was no communication between training entities. There was not a feedback system in place to determine whether training was meeting requirements or improved job performance. ERNT proposed realignment of Navy training using a systems-level approach under the HPSM. The proposed HPSM used a 4 quadrant process which is rooted in the basic concepts of the Systems Engineering process:

- Define Requirements (Q1)
- Design Solutions (Q2)
- Develop, Build and Integrate Tools (Q3)
- Execute and Measure Effectiveness (Q4) (ERNT, 2001, p. 33.)

Requirements definitions (Q1) is centered on breaking down jobs and job tasks into behaviors and competencies, then ranking them on importance to form job performance standards. The requirements should be different for different stages in a career. Design of solutions (Q2) incorporates the science of learning and human performance sets. Analysts and SME take the requirements developed in Q1 and determine the best methods to meet them.  In addition to solution options, performance metrics and cost analysis should be considered. Once a solution option is selected, the choice should be developed (Q3). The solution option can include any mix of formal classroom instruction, CBT, distributed learning, manpower adjustments, job performance aids, job re-design/automation, etc. (ERNT, 2001)

If training is the solution that is accepted, training occurs and is measured in Q4. If multiple organizations are involved in the training it should be integrated so steps are not duplicated. The measurement should include 4 levels of feedback:

- Is the student enjoying the experience?
- Is the student learning facts?
- Is the Sailor more productive in prescribed tasks?
- Is the team/command more proficient because of the performance enhancement solution? (ERNT, 2001, p. 35.)

The recommendation for meeting Navy training objectives involves integrating training technology, human performance requirements, and the science of learning into the HPSM and melding it into a framework for determining solution options for performance issues. From the study of the science of learning, it is recognized that individuals respond differently to different techniques, learning is improved when tailored to the individual; retention is improved when more than one learning method is used, and the transfer of learning is more effective when supported by feedback, support, and practice (ERNT, 2001). Thus, learning is most effective when it features multiple methods, and the Navy Learning Model includes instructor-led training, reference-based learning, computer-mediated learning, and collaborated learning with reinforcement through OJT and mentoring (ERNT, 2001).

To improve Navy training, the establishment of a Human Performance Systems Organization (HPSO) to design near and long-term solutions has been recommended. The HPSO would handle the QI and QII functions of the HPSM to include:

- Apply Science of Learning and Human Performance considerations to Navy job requirements
- Develop performance measures
- Generate knowledge, skill, abilities & tools (KSATs)
- Assess the cost effectiveness (e.g., return on investment) of performance and learning solutions
- Develop and maintain Navy-wide strategic learning plans (simulators, e-Learning, virtual reality, CBT, etc.) (ERNT, 2001).

#### *b. Training Alignment*

ERNT recommended establishing an integrated training organization to eliminate redundancy and maximize resources. The proposed organization would collect performance data and results, recommend improvements, assess cost effectiveness and return on investment (ROI), control all training activities and processes, manage all schoolhouse training, and have its own funding (ERNT, 2001).

Additionally, training could be aligned at the OPNAV level. Training requirements were fragmented across several OPNAV branches. At the OPNAV level, the training re-organization would be responsible for Navy-wide training policies, establish training requirements processes, and establish and monitor a training performance tracking system (ERNT, 2001).

#### *c. Emphasize Human Performance in Acquisition*

The group recommended 1) Considering training and human performance in the design and acquisition of systems, 2) Holding program managers accountable and ensure training is considered early in the design process, 3) Developing a Navy instruction that guides the development of navy training systems, and 4) Utilizing HSI in systems development (ERNT, 2001).

#### *d. Establish a Lifelong Learning Continuum*

ERNT believed that establishing a lifelong learning continuum would improve performance and provide better use of "human capital." Additionally, they placed an emphasis on blended learning solutions and encouraged the use of learning tools such as the Internet. ERNT's proposals relied on the idea of an "empowered individual learner," who would be personally responsible for his/her own learning, would be a creative participant in the training process, would achieve proficiency in their job, would learn throughout their career, and enjoys the career training process (ERNT, 2001).

## E. 2009 NAVY IG REPORT

### 1. Background

The Navy IG commenced a review of CBT in the Navy after hearing concerns from the Fleet about the level of knowledge of sailors reporting to ships from A schools. The IG conducted a thorough review of Navy training as it related to CBT by conducting interviews and studies at all levels of the training continuum—policy makers, schoolhouses, students, and afloat units. The goal of the IG report was to answer the question, "Does the Integrated Learning Environment (ILE), as supported by CBT, meet its goal of delivering a trained and 'Sailorized' asset to the Fleet?" (Naval Inspector General, 2009, p. 1) The report included a review of existing training policy, assessed effectiveness of that policy, and identified areas of improvement while offering potential solutions. The policy review included a review of the 2001 ERNT *Revolution in Training* report (Naval Inspector General, 2009).

### 2. Findings

The IG report found deficiencies in 11 key areas, several of which related to the *Revolution in Training* report or changes that were implemented because of it:

#### *a. Curriculum Design and Development*

The ILE was established as a result of the *Revolution in Training Report*. The purpose of the ILE is to establish an infrastructure for electronically-delivered training material and to provide an administrative and technical repository for the distribution, storage, and maintenance of Navy learning material (Naval Inspector General, 2009). In order for a course to be delivered via CBT, Department of Defense (DoD) Directive 1322.18 *Military Training*, states that electronic training must be the first alternative when choosing the most cost-effective training solution. The directive also states that DoD members must receive the most effective training possible (Department of Defense, 2009). These statements imply that some sort of analysis of alternatives (AOA) must be conducted when determining the optimal medium of training delivery.

The IG report revealed that there were no standards for the development of CBT material. The quality of CBT material varied depending on the program sponsor, so different pieces of equipment have different types and quality of CBT material, meaning that the effectiveness of the material could be highly variable. There was little evidence to show that SMEs had input in the development or testing of CBT material. In many cases, old lecture material was quickly converted into CBT format, but there was not a process in place to verify the accuracy of the information. In some cases, assessment tests had incorrect answers, and facilitators developed workarounds to enable students to pass the tests (Naval Inspector General, 2009).

In addition to the development of the CBT material, another problem was that more than 30% of all CBT material did not reside on the ILE. In the case of SECRET coursework, the Secret Internet Protocol Router Network (SIPRNET) structure was not fully developed, forcing schoolhouses to maintain SECRET CBT coursework on local SIPR servers (Naval Inspector General, 2009).

There was very little evidence to suggest that any AOAs were conducted to determine whether CBT was the appropriate choice for any of the CBT modules. Also, there did not appear to be any standardization for development, testing, and funding of CBT materials as specified in the ERNT report.

#### *b. Life Cycle Management (LCM)*

DoD Instruction 1322.20, *Development and Management of Interactive Courseware (ICW) for Military Training*, states that DoD Component Heads are to "Provide life-cycle management (LCM) for their Interactive Courseware (ICW) programs" (Department of Defense, 2004). The IG found that LCM for CBT programs usually did not account for program and curriculum updates. Contrary to what ERNT expected, these problems resulted in program updates taking more time to take effect than traditional ILT. Facilitators were forced to conduct ILT or develop workarounds in the CBT programs (Naval Inspector General, 2009).

#### *c. Delivery Systems for Web-Based Technology*

In A schools, CBT is conducted in an electronic classroom (ECR) environment. The ECR consists of several PCs connected to a server or a farm of servers. Student progress, exam scores, and transcripts are managed on a Learning Management System (LMS) that resides on the same server as the CBT it supports (Naval Inspector General, 2009).

As of the 2009 report, more than 26,000 computers were linked to ECRs. The average age of the computers was approximately 6 years (Naval Inspector General, 2009, p. 5). The IG group found that most ECRs needed new equipment and the old equipment caused several problems for students due to equipment malfunction, low bandwidth, and poor infrastructure. Students expressed frustration with the ECRs because of these problems. They reported that it created a distracting environment that disrupted their learning opportunities.

Since ECRs are managed by different program sponsors depending on the system, the quality of LMS varied from site to site (Naval Inspector General, 2009). The LMS was designed to reduce administrative burden on facilitators, but in some cases, they doubled or tripled time spent on administrative duties due to poor construction.

#### *d. Electronic Instruction and "Generation Y"*

*Revolution in Training* highlighted the need to compete with modern industry to recruit talented personnel. ERNT discovered that modern organizations used e-learning as a training tool and suggested that the future workforce Navy training system should capitalize on e-learning technology to attract a savvier workforce. While it is true that "Generation Y" has grown up in the computer age and are technologically savvy, the IG found that it did not necessarily mean that they were more accustomed to learning on computers. Sailor interviews revealed that they preferred to use technology for entertainment and communication. Sailors were more familiar with ILT and were not accustomed to learning in front of a computer for an entire class-day (Naval Inspector General, 2009).

#### *e. Instructional Design*

The IG report cited modern learning theory, specifically the visual, auditory, and kinesthetic (VAK) model (Naval Inspector General, 2009). According to VAK theory, students learn mostly through sight, hearing, and touch, with one or two of the three methods being the most predominant. Proponents of the VAK model suggest that effective training should include all three elements in order to reach all styles of learners (MacKay, 2007). The IG found that most Navy CBT did not effectively capture all of the VAK elements. Typically, CBT always addressed visual learning, sometimes addressed audio learning, but did not address kinesthetic learning at all (Naval Inspector General, 2009).

CBT also did not effectively capture the four key elements of adult learning: motivation, reinforcement, retention, and transference (Lieb, 1991). Adult learners must have an incentive to learn such as a comfortable learning environment, a topic that reasonably challenges them, or a sense of importance about the material they are learning. Learners should be rewarded for positive outcomes and made aware of mistakes. They must be able to retain and apply the information they have learned when in the workplace (Lieb, 1991). These elements were neglected because Navy CBT focused on speed of completion, removed instructors from the classroom, offered no incentives, and removed redundant training (Naval Inspector General, 2009). Each of the above points will be explained in more detail in the sections to follow.

#### *f. Speed of Completion vs. Knowledge Mastery*

Incentive to learn has been cited as a key element of adult learning. In Navy CBT, the only incentive offered is to complete the course as quickly as possible. Because of this, students click through the training programs as quickly as possible in order to get to the exam. Since there is no penalty for failure, students try to learn enough information to pass the exam and then "data dump" what they have learned immediately after (Naval Inspector General, 2009). If they fail the exam, they can go back and try again until they pass, so there is little incentive to actually learn.

#### *g. The Shift from Instructor to Facilitator*

In ILT, instructors were SMEs in the field they were teaching. Typically, they had just come from the fleet and had worked on the equipment that they were teaching on. They had operated equipment, maintained equipment, and restored casualties. Additionally, they were senior sailors and served as examples of how sailors should conduct themselves personally and professionally. If a student had a question about the material, the instructor could readily provide the answer and, most likely, had a personal "sea story" to offer that related to the material. Additionally, since ILT occurred in a group environment, several sailors may have had the same question, so the exchange of information benefitted the entire group.

In the Navy CBT setting, however, this is not the case. Most facilitators are civilian contractors who were in the ECR to enforce classroom rules, monitor progress, and attend to computer problems. Active duty facilitators hold the 9502 Instructor NEC, but they aren't trained in CBT teaching (Naval Inspector General, 2009). Since CBT is done individually and is self-paced, facilitators respond to questions individually; however, since most facilitators aren't trained in the topic, they are unable to answer the questions appropriately. Sailor interviews revealed student frustration with this issue (Naval Inspector General, 2009). Also, since answers are given one-on-one, there is no consistency from student to student. This is more of an issue with how CBT was implemented than a statement to the quality of the material contained within. It does illustrate, however, that there were several problems surrounding the CBT program that contributed to the problems experienced in the Fleet.

#### *h. Elimination of Redundancy*

The IG found that knowledge retention is related to repetition of material (Naval Inspector General, 2009). In ILT, information is taught orally and reinforced through practical application in laboratory settings. Since the goal of CBT is to reduce training time, repetition of material was eliminated. The result is that upon arriving to C school (after A school), students lack the basic knowledge required to begin the next course. In one example, the Aegis Training Readiness Center (ATRC) constructed an Awaiting Instruction Program (AIP) to re-teach material from A school in order for students to proceed on to C school (Naval Inspector General, 2009).

#### *i. Transference of "A" School Training to the Fleet*

The lack of motivation, retention, and repetition in the Navy CBT environment leads to poor transference of skills when sailors arrive to the fleet. In addition to this, the IG report found that most CBT training was not linked to KSATs (Naval Inspector General, 2009). Because of this, sailors arrive to ships unaware of the equipment they are working on or the tools they need to use. The IG noted that the expectations of the Fleet were not met by the training provided in the classrooms. Fleet leadership expects a "turnkey ready" sailor who arrives to the ship knowledgeable in their field and able to work with little training. In Fleet interviews, some commands reported that qualification time is nearly double what it was before the introduction of CBT (Naval Inspector General, 2009). The problem faced by the fleet is that either they take the extra time to train sailors properly and take time away from other important tasks, or they neglect the training to focus on operations. Either way, sailors and afloat units suffer.

#### *j. Training Pushed to the Fleet*

Sailors arriving to the fleet under CBT do not usually meet the required KSATs upon reporting on board. Because of this, ships must take the time to train new sailors up to acceptable standards. This task becomes difficult under current conditions due to increased OPTEMPO, increased training requirements, more complex equipment, reductions in manning, and the loss of additional sailors to fill Individual Augmentee/Global War on Terrorism Support Assignments (IA/GSA). Additionally, the shift from instructor to facilitator removed experienced sailors from divisions; sailors returning to the Fleet from instructor duty provided a valuable asset to a division (Naval Inspector General, 2009).

### 3. Navy IG Report Conclusions

The IG report noted that there were both positive and negative impacts of ERNTs recommendations to switch to CBT, and also recommended solutions. The report noted that training time had been successfully reduced, which resulted in cost savings in manpower and infrastructure (Naval Inspector General, 2009).

Among the negative impacts the Navy's implementation of CBT were that there is no centralized authority that governs standardization, development, content, contracting, or life cycle management of CBT. Also, CBT courseware isn't aligned with the KSATs that sailors require in the fleet. There needs to be a method for afloat units to provide feedback to schoolhouses for course improvements. Finally, schoolhouses should shift back from facilitators to instructors (Naval Inspector General, 2009). Learning environments that incorporate CBT with other teaching methods would allow instructors to return to the classrooms and provide the example that young sailors need.

## F. OTHER REPORTS

Two reports, released in 2010 and 2011, addressed the results of the changes made in the Navy training system. These reports are summarized in this section.

### 1. Military Readiness: Navy Needs to Reassess its Metrics and Assumptions for Ship Crewing Requirements and Training (GAO Report)

In 2010, GAO released a report, *Military Readiness: The Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training* at the direction of the House Armed Services Committee. The report examined the impacts of changes to both crew size and training. This portion of the thesis will examine the training portion of the GAO report.

The GAO report noted that the Navy has made significant changes to the way it delivers training, as described in previous sections of this thesis. In assessing these changes, GAO found that the Navy had reported significant reductions in course length and cost but lacked data on student performance. The Navy IG report highlighted the importance of tying CBT courses to KSATs and went on to note that fleet leadership felt that sailors did not meet the requisite KSATs upon reporting on board. GAO furthered this by commenting that the Navy has not established any quantifiable way to measure whether CBT has impacted a sailor's KSATs once they report to a ship (GAO, 2010). The Navy did conduct one study in an attempt to compare ILT and CBT, but they examined only one instance of training and did not perform any follow-on assessments. The study was performed by the Center for Naval Engineering (CNE). CNE examined one class of engineering students. The class was divided into two groups, one that received training material via ILT and another that received CBT. CNE reported that the CBT group exhibited higher scores in level of knowledge (LOK) exams administered after the training (GAO, 2010). Unfortunately, no follow-on work was conducted to follow sailors to the fleet and re-test them at various time intervals. Since the study was completed only with one test group, there is not enough data to examine adequately the validity of the results. Navy officials informed GAO that they would like to perform additional studies, but cited difficulties in coordinating with training entities and afloat units. Another difficulty in comparing ILT and CBT effectiveness is that there is no baseline ILT data available to compare with any CBT data that may be collected in the future (GAO, 2010). GAO findings on sailors' level of knowledge (LOK) upon arriving to ships echoed the Navy IG reports that sailors were not arriving with sufficient comprehension of the KSATs for their job. Fleet interviews with sailors 11 afloat units revealed additional training time was required to bring CBT-trained sailors up to speed (GAO, 2010). The interviews also echoed Navy IG interview comments that cited the difficulties of providing the required OJT under reduced manning and increased requirements conditions. Some senior leaders reported that the LOK in new sailors was so low, that the senior leaders often stepped in to directly supervise, or even perform, maintenance actions that were previously routine for junior sailors (GAO, 2010).

In some cases, commands resorted to establishing their own classrooms to bring newly-reporting sailors up to speed. For example, Afloat Training Groups (ATGs) in seven Fleet Concentration Areas (FCAs) established a 4-week Surface Warfare Officer (SWO) Introduction Academy that teaches newly-arriving officers basic division officer fundamentals required upon arrival to their ship (Jones, 2009). This was added as a supplement to "SWOS-in-a-box," a set of training CDs that new officers are expected to complete when reporting on board, which was originally meant to replace the 6-month Surface Warfare Officer School (SWOS) that officers completed before reporting to their first commands (GAO, 2010). Based on their study, GAO recommended that the Navy develop performance metrics to assess the impacts of its training programs on readiness (GAO, 2010).

### 2. Military Readiness: Navy's Report to Congress on the Impact of Training and Crew Size on Surface Force Material Readiness (GAO Report)

In 2011, GAO released *Military Readiness: Navy's Report to Congress on the Impact of Training and Crew Size on Surface Force Material Readiness* in response to

DONs report to Congress of the same name. In the DON report, Navy officials conceded that, “eliminating some training courses and shifting to more computer-based training resulted in crews arriving on board their ships not fully ready to perform apprentice-level maintenance actions and contribute effectively to existing material demands” (GAO, 2011, p. 4). The Navy report also concluded that training and manning are two (of several) contributors to fleet material readiness and that the changes in each resulted to negative impacts in material readiness (GAO, 2011).

As a result, the Navy announced plans to change aspects of their training and readiness strategies. GAO found, however, that the Navy “did not perform sufficient analysis to verify the information used to support its conclusions and recommendations” (GAO, 2011, p. 6). The Navy used information from old reports and inspections, but did not conduct any independent analysis to check the validity of the data or assumptions contained in those reports. While the recommended changes may prove to be effective, they are not rooted in the sort of analysis that is required before coming to such decisions. The analysis provided in Chapters V–VII of this thesis will make independent analysis of a particular system, the AN/SQQ-89(v) sonar, to show the impacts of the change to CBT on maintenance.

## G. SUMMARY

The Navy’s Revolution in Training strategy attempted to take advantage of e-Learning technology to achieve savings in cost and training time while maintaining equal or superior quality of learning. Several of the ERNT recommendations were implemented, resulting in the consolidation of training commands and the implementation of CBT in A and C schools. Navy IG and GAO reports demonstrated that while cost and training time savings were achieved, the quality of sailor reporting to the Fleet was not as well prepared as ILT-trained sailors of the past. The result is that poorly-trained sailors may have contributed to declining material readiness in the Fleet. The next section of this thesis examines Navy maintenance practices and highlights the findings of the *2010 Fleet Review Panel on Surface Force Readiness* report.

# III. MAINTENANCE

## A. INTRODUCTION

Navy maintenance occurs on three levels: organizational level (O-level), intermediate maintenance (IM) activities, and depot level. This section of the thesis will discuss all three maintenance levels. Additionally, this section will discuss changes made to the maintenance process in 2003 which were reported on in the *2010 Fleet Review Panel on Surface Force Readiness* (known as the Balisle Report for its chairman Vice Admiral (VADM, Retired) Phillip Balisle), a report that discussed declining Fleet readiness as a result of changes to training, maintenance and manning policies in the early 2000s.

## B. SHIPBOARD MAINTENANCE AND ORGANIZATIONAL LEVEL MAINTENANCE

Shipboard maintenance begins with the Planned Maintenance System (PMS). PMS is governed by Naval Sea Systems Command (NAVSEA) Instruction 4790.8B, *Ship's Maintenance and Material Management (3-M) Manual*. The instruction outlines the requirements for PMS on shipboard systems and equipment (Naval Sea Systems Command, 2003). The purpose of PMS is to provide ships with the means to plan, schedule, and perform preventive maintenance on ships and to identify potential equipment problems before the equipment fails.

Planned maintenance is scheduled by the Work Center Supervisor (WCS) for all equipment in the division and is recorded on the PMS schedule. Maintenance personnel must be 3-M qualified and meet rate (skill level) requirements for performing a particular PMS check as specified on the Maintenance Index Page (MIP) (Naval Sea Systems Command, 2003).

If corrective maintenance is required, the maintenance is reported, scheduled, and performed through organizational level (O-level) shipboard maintenance. All maintenance actions, including deferred maintenance actions, require a Job Sequence Number (JSN). Deferred maintenance actions refer to maintenance that either requires assistance from an outside activity or work center, is not expected to be accomplished by ship's force during the prescribed time period, is an uncorrected discrepancy noted by an outside inspecting agency, or is required to correct an existing discrepancy that could cause harm to personnel or equipment. All deferred maintenance actions are recorded on the Current Ship's Maintenance Project (CSMP), a consolidated list of all active ship's maintenance actions that provides an accurate picture of the ship's material condition. The CSMP is used by outside activities to schedule repair actions. Ship maintenance actions are reported in Navy Visibility and Management of Operating and Support Costs (VAMOSC), under Unit Level Consumption and Manhours—Organizational Corrective Maintenance.

## C. INTERMEDIATE MAINTENANCE (IM)

IM is "normally performed by Navy personnel onboard tenders, repair ships, Shore Intermediate Maintenance Activities (SIMAs), aircraft carriers, and fleet support bases." (Naval Sea Systems Command, 2003, pp. I-5) IM jobs are deferred CSMP jobs that are beyond the capability of ship's force and are sent off-ship for completion. IM is tracked in Navy VAMOSC under Maintenance – Intermediate.

## D. DEPOT LEVEL MAINTENANCE

Depot maintenance jobs are deferred CSMP jobs that are beyond ship's force capability and are performed by outside activities such as public shipyards. Depot level maintenance "requires major overhaul or a complete rebuilding of parts, assemblies, subassemblies, and end items, including the manufacturing of parts, modifications, testing, and reclamation." (Naval Sea Systems Command, 2003, pp. I-5). Depot maintenance is reported in Navy VAMOSC under Maintenance and Modernization – Depot, Other Depot.

## E. BALISLE REPORT

In 2009 VADM (Ret.) Phillip Balisle was directed to conduct a Fleet Review Panel (FRP) of surface force material readiness. The review covers the "man, train, and equip" domain areas and studies the effects of changes in training, manning, and maintenance in the 2000s and how these changes impacted Fleet material readiness (Balisle, 2010). Since training was discussed in depth in Chapter II, this review of the Balisle Report will focus on the changes in manning and maintenance.

### 1. Optimum Manning

The concept of "optimum manning" was introduced by the CNO in 2001. The purpose of "optimum manning" is to maximize efficiency and ensure that ships have the proper amount of personnel on board to support mission accomplishment. Optimum manning is based on manning levels required for underway watch standing requirements and does not take other duties such as OJT, maintenance, and space preservation, or in-port work requirements into account. As a result of "optimum manning," 4,052 billets were removed from Navy ships from 2001–2009 (Balisle, 2010).

While billets were removed from ships, requirements such as maintenance, damage control watches, training, and in port duties were not reduced. The result is that there are fewer people available to meet the same requirements. This causes major problems for ships like the DDG-51 class, where manning was reduced from 317 to 254 sailors from 1998–2009 (Balisle, 2010). Since the optimum manning initiative relies on the right sailors with the right skills, it is highly dependent on the revolution in training. The failures of revolution in training described in the previous section exacerbated the problems experienced with the optimum manning initiative since sailors were not arriving on board with the right KSATs. The result is undermanned ships with poorly trained sailors with not enough time or know-how to perform routine maintenance actions.

In addition to reduced fleet manning, shore facilities also received manning cuts. By 2006 SIMAs and Regional Support Organizations (RSOs) were disestablished (Balisle, 2010). This means that maintenance that is intended for IMAs is pushed back to ship's force, which is undermanned and poorly trained.

### 2. Maintenance

Class Maintenance Plans (CMPs), a maintenance program designed to ensure that ships meet or exceed their designated service lives, were discontinued when the organization that managed CMPs was disestablished in 1995. In 2000, Integrated Class Maintenance Plans (ICMPs) were established to fill the void. ICMPs are managed by a port engineer, the chief engineer, and the ship's commanding officer. The intent of the ICMP is that ships would manage their own maintenance plans in conjunction with the port engineer, but typically, near-term maintenance takes precedence over long-term goals (Balisle, 2010).

As previously noted, closures of SIMAs and the regionalization of maintenance activities resulted in backlogs in maintenance. In addition to the shrinking shore workforce, maintenance availabilities were shortened from 15 weeks to 9 weeks (Balisle, 2010). These actions result in equipment being out of commission for longer periods of time.

Finally, changes in PMS were made because ships couldn't meet maintenance requirements due to reduced manning. Maintenance requirements were either eliminated or extended in periodicity. The intent was to shift maintenance requirements to shore facilities, but since manning was reduced ashore, many requirements went away completely (Balisle, 2010). The elimination and extension of maintenance requirements can lead to more opportunities for equipment to become inoperable, resulting in degraded Fleet readiness.

## F. SUMMARY

As designed, PMS is intended to keep equipment operational by conducting scheduled maintenance checks and correcting discrepancies as they are found. Discrepancies are recorded with a JSN and included on the CSMP. Deferred maintenance is sent to IMAs or Depot level repair as required. The Balisle Report, however, found that changes in manning, training, and maintenance put severe stresses on the system resulting in degraded Fleet material readiness. Poorly trained sailors reporting to "optimum manned" ships were unable to keep up with maintenance requirements. At the same time, SIMAs were closing and maintenance availabilities were shortened. Backlogged jobs resulted in increased maintenance costs because more time was required to complete the work. The Balisle report showed that changes in the training program were related to maintenance and material readiness. The sections that follow will attempt to show a direct relationship between training and maintenance as it relates to the AN/SQQ-89(v) sonar system.

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# IV. DEPARTMENT OF THE NAVY BUDGET

Training elements of DON Budget Reports from FYs 2000 to 2012 were analyzed to determine the amount of money spent on training each year during the 2000s. The ERNT *Revolution in Training* report and subsequent Navy IG and GAO reports cited reduced training costs by relating training as a percentage of the overall budget. In order to further examine this issue, data from DON Biennial Budget Estimates for Operations and Maintenance (O&M) reports from FYs 2000 to 2012 were used to gather budget information for the following categories:

- Training and Recruiting
    - Recruit Training
    - Specialized Skill Training
- Ship Operations
    - Ship Operational Support and Training
    - Intermediate Maintenance
    - Depot Level Maintenance
- Ship Maintenance
    - Emergent Repair
    - Intermediate Maintenance (Note: IM budget items were moved from Ship Operations to Ship Maintenance in FY2003)

All budget reports included 3 years of budget data. For instance, the FY2000 report included budget data for FYs 1998, 1999, and 2000. The numbers contained in the report represent the Total Obligation Authority (TOA) for the given FY in the last year it was reported.

For example, budget data for FY2000 were gathered from the FY2000 budget report. TOA is:

> The sum of: 1.) all budget authority (BA) granted (or requested) from the Congress in a given year, 2.) amounts authorized to be credited to a specific fund, 3.) BA transferred from another appropriation, and 4.) unobligated balances of BA from previous years which remain available for obligation. In practice, this term is used primarily in discussing the DoD budget, and most often refers to TOA as “direct program” which equates to only (1) and (2) above. (Department of Defense, 2011)

Budget information for the categories listed above was gathered for FYs 2000 through 2010 and converted to constant FY2010 dollars. The following data were gathered (Table 1):

| *All figures in constant FY10 dollars | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FY | Training and Recruiting ($M) | Recruit Training ($T) | Specialized Skill Training ($T) | Ship Operational Support and Training ($T) | Intermediate Maintenance ($T) | Depot Level Maintenance ($M) | Emergent Repair ($T) | Total DON Budget ($M) |
| 2000 | 2,358 | 6,772 | 327,042 | 684,407 | 474,492 | 3,277 | | 112,079 |
| 2001 | 2,541 | 7,086 | 347,367 | 635,324 | 480,792 | 3,153 | | 118,345 |
| 2002 | 2,634 | 6,962 | 395,360 | 597,769 | 474,449 | 3,533 | | 127,071 |
| 2003 | 2,883 | 7,427 | 455,041 | 705,575 | 506,262 | 5,473 | 362,044 | 146,816 |
| 2004 | 2,158 | 11,850 | 489,309 | 740,478 | 710,710 | 4,527 | 285,758 | 140,378 |
| 2005 | 2,219 | 7,775 | 509,350 | 697,400 | 611,146 | 4,799 | 249,499 | 149,122 |
| 2006 | 2,232 | 9,638 | 548,727 | 671,433 | 673,440 | 4,625 | 228,398 | 156,399 |
| 2007 | 2,262 | 9,941 | 575,365 | 678,651 | 719,422 | 4,369 | 225,695 | 159,355 |
| 2008 | 2,314 | 10,224 | 545,769 | 718,552 | 727,442 | 5,127 | 286,311 | 166,884 |
| 2009 | 2,296 | 11,357 | 602,726 | 697,680 | 845,443 | 5,215 | 242,450 | 167,982 |
| 2010 | 3,204 | 10,437 | 593,979 | 717,586 | 1,067,823 | 6,265 | 303,110 | 176,979 |

Table 1. DON Budget Data FYs 2000–2010 (constant 2010 dollars) (Department of the Navy, 2000—2010)

Figure 1 shows that from FYs 2000-2010, the Training and Recruiting budget was fairly stable. The budget rose steadily from FY 2000 to FY2003, but dropped and remained stable after that. The growth rate from FYs 2003–2010 was 1.39%. The budget change coincides with the training realignment measures in 2003. When examining the Specialized Skills Training portion of the training budget, however, training costs nearly doubled over the FY 2000–2010 period (Figure 2). The growth rate from FYs 2003–2010 was 3.82%. This suggests that cost savings were realized in areas other than actual training delivery in A and C schools. This could be attributed to realignment of training organizations and consolidation of schoolhouses.


Figure 1. Training and Recruiting ($Millions) FYs 2000–2010

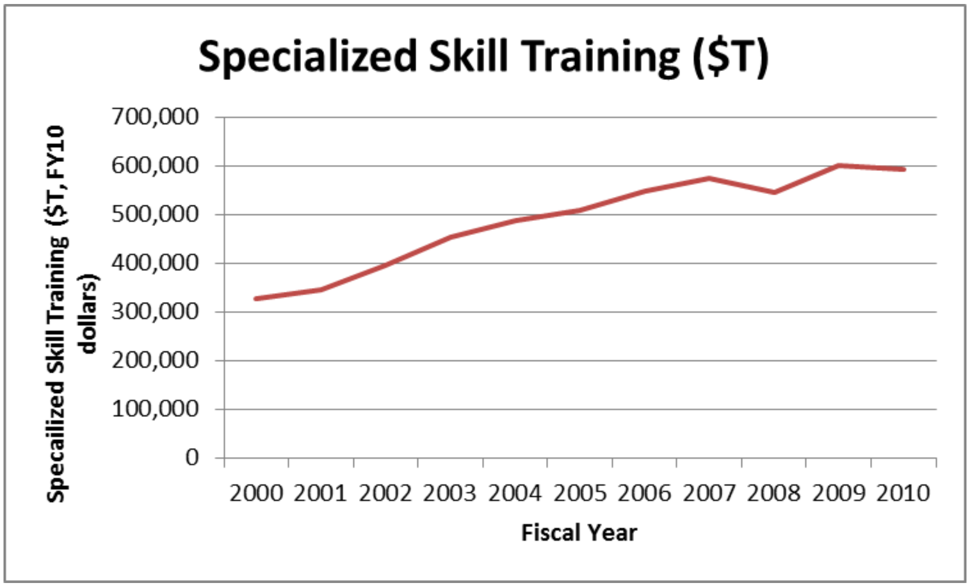


Figure 2. Specialized Skill Training ($Thousands) FYs 2000–2010

Over the same time period, the overall DON budget rose significantly, with a growth rate of 2.57% from FYs 2000–2010 (Figure 3). The IG and GAO reports noted that training costs had decreased. When examined as a percentage of the total budget, that is the case, but only because the total budget increased while the training budget remained fairly flat.

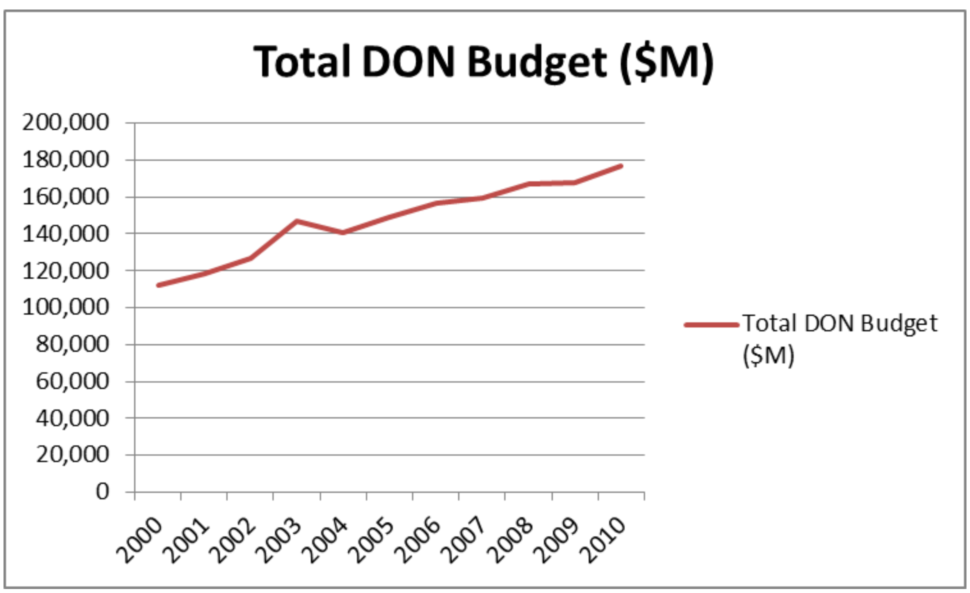


Figure 3. Total Department of the Navy Budget ($Millions) FYs 2000–2010

While the overall training budget was fairly flat during the 2000s, the maintenance budget saw increases (Figures 19 and 20). IM budget figures more than doubled and Depot level maintenance figures nearly doubled during the 2000s.

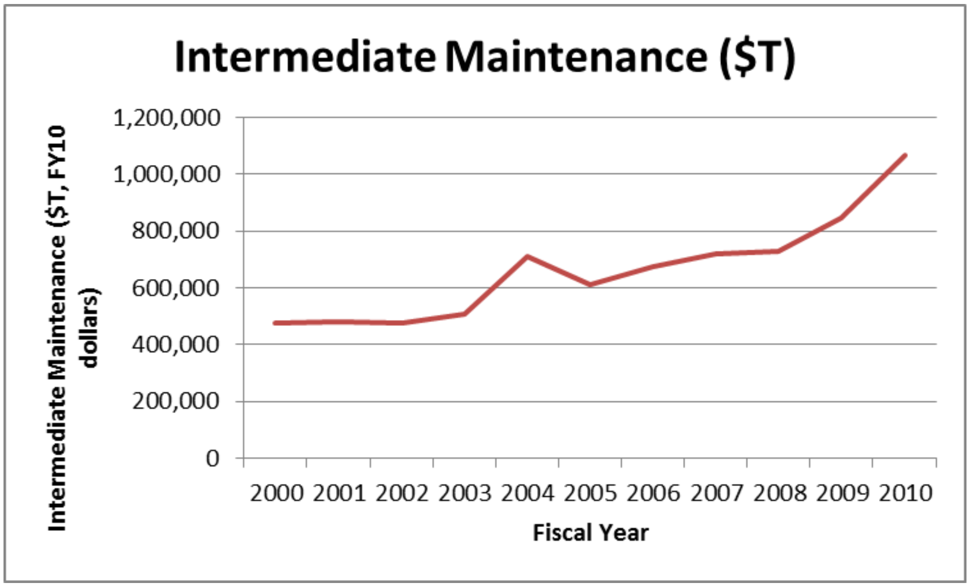


Figure 4. Intermediate Maintenance ($Thousands) FYs 2000–2010

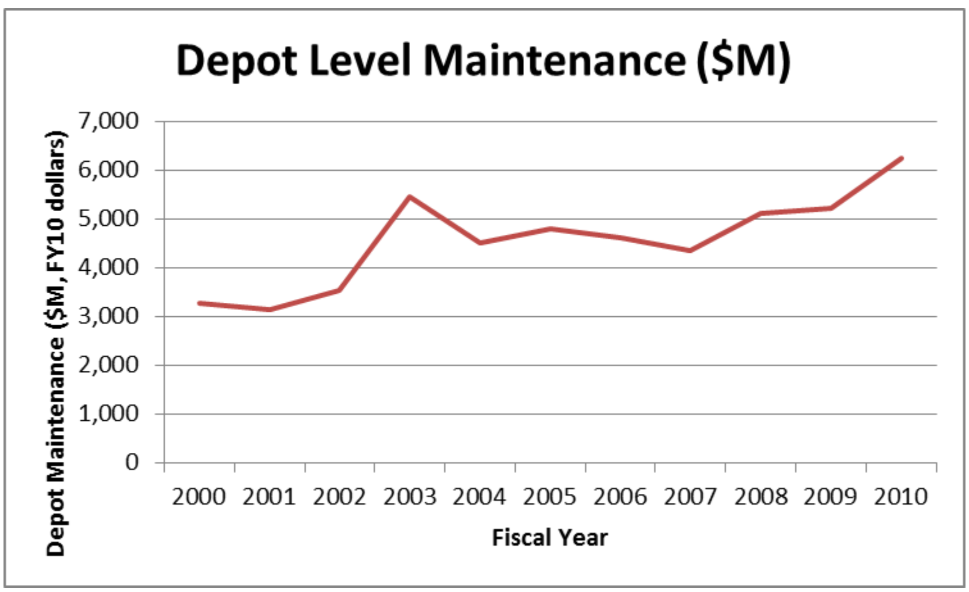


Figure 5. Depot Level Maintenance ($Millions) FYs 2000–2010

The rise in IM and depot-level maintenance costs while training costs remained flat suggests that there may be a relationship between training policy changes that lead to poorly trained sailors and rising Fleet maintenance costs. Since there are several confounding variables at the macro level such as changes in OPTEMPO, manning policies, and maintenance policies, it is difficult to draw any conclusions. The aim of this thesis is to examine the relationship between training costs and rising maintenance costs by focusing on the AN/SQQ-89(v) sonar system.

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# V. AN/SQQ-89(V) SONAR SYSTEM

## A. INTRODUCTION

The Navy introduced several major changes to training, maintenance and manning policies during the early part of the 2000–2010 decade. Interviews conducted in 2008 with Fleet leadership indicate that senior leaders were unhappy with the quality of sailor arriving to the Fleet. Some senior enlisted leaders reported that they had to directly supervise or even perform maintenance that was once routine for junior sailors (Naval Inspector General, 2009). These interviews suggest that changes in the training program may have led to second-order effects in maintenance, causing Fleet maintenance costs to rise. On the other hand, the changes made in maintenance and manning may have also been contributors. In order to isolate the training variable as the contributor to rising maintenance costs, this thesis will focus on the O&S costs of a single Navy system, the AN/SQQ-89(v) sonar system, and examine how the conversion to CBT affected maintenance costs in that system. Data presented in Chapter VI, Results, will show that manning levels for the STG rate did not change significantly from FYs 2000–2010, effectively eliminating manning as a contributor for the AN/SQQ-89 O&S costs and focusing the study on training and maintenance.

## B. DESCRIPTION

The AN/SQQ-89(v) surface ship Anti-Submarine (ASW) Warfare combat system (referred to as "the 89" in the rest of this paper) is an integrated network of sonar systems designed to search, detect, classify, and engage ASW threats. The system is currently installed on CG-47 class cruisers, DDG-51 class destroyers, and FFG-7 class frigates. The 89 uses a variety of sensors that can transmit (active) and receive (passive) acoustic data in order to detect and classify threats. Data from the sensors can be correlated and targets can be localized using Target Motion Analysis (TMA) to generate a firing solution for weapons systems (Jane's Information Group, 2010). The 89 system must include at least two of the following subsystems (Naval Sea Systems Command (NAVSEA), 1998):

- AN/SQR-19(v) (series) Sonar Receiving Set
- AN/SQQ-28(v) Sonar Signal Processing System
- AN/SQS-56 or AN/SQS-53 (series) Sonar Detecting – Ranging Set
- AN/UYQ-25 (series) Sonar In-Situ Mode Assessment System (SIMAS)
- MK116 Underwater Fire Control System (UFCS) or Weapons Alternate Processor (WAP) (Jane's Information Group, 2010)

Data from these systems are displayed on operator consoles in the Sonar Control room of a surface ship. Operators are designated a particular sensor to monitor (19 operator, 28 operator, 53 operator, etc.) and the Sonar Supervisor uses the data to determine the classification of a contact. The 89 system can consist of the following components:

**1. AN/SQR-19(v)**

The AN/SQR-19, 19A and 19B Sonar Receiving Sets are versions of the Tactical Towed Array Sonar (TACTAS). The TACTAS consists of an array of hydrophones approximately a mile long towed behind a ship. The hydrophones passively detect sonar contacts at long ranges (Jane's Information Group, 2010). The data from TACTAS are displayed in Sonar Control and can be used to determine placement of sonobuoys for target localization. TACTAS is not available on Flight IIA DDG-51 class destroyers.

**2. AN/SQQ-28(v)**

The AN/SQQ-28 Sonar Signal Processing System is used to process active and passive acoustic data from sonobuoys dropped by the SH-60 Seahawk Light Airborne Multi-Purpose System (LAMPS) MK III helicopter. The sonobuoys provide long-range detection by using helicopters to extend the ship’s normal detection range. The 28 is available on CG-47 class ships beginning with hull number 56 and in all DDG-51 class ships (Jane's Information Group, 2010).

### 3. AN/SQS-56

The AN/SQS-56 is a hull-mounted active/passive sonar. The 56 is available only on FFG 7 class ships. In active mode, the 56 can detect contacts up to 5 nautical miles (NM). In passive mode, the 56 can detect to approximately 9 NM (AN/SQS-56 Sonar).

### 4. AN/SQS-53

The AN/SQS-53A, 53B, 53C, and 53D sonars are long range, high power, hull-mounted sonars. The 53 series can be found on CG-47 and DDG-51 class ships. The sonar has both active and passive modes. Target data from the 53 can be sent to the MK116 UFCS to prosecute contacts with shipboard weapons (Jane's Information Group, 2010).

### 5. AN/UYQ-25

The AN/UYQ-25 SIMAS performs environmental assessments to aid Sonar Supervisors in deciding the optimal employment of 89 sensors. SIMAS processes environmental data from Expendable Bathythermograph (XBT) probes that measure temperature versus depth in an operating area. The XBT data are used to determine detection range predictions so supervisors can employ their sensors in the best manner (Jane's Information Group, 2010). SIMAS is installed on FFG-7, CG-47, and DDG-51 class ships.

### 6. MK116

The MK116 UFCS takes sensor data from the 19, 28, and 53 and integrates them with non-acoustic sensors such as radar and off-ship data from helicopters to generate a firing solution using TMA. The firing solution is used to fire shipboard torpedoes or Vertical Launch Anti-Submarine Rockets (ASROC). The MK116 is installed on CG-47 and DDG-51 class ships (Jane's Information Group, 2010).

### 7. Weapons Alternate Processor

The WAP is the fire control processor for FFG 7 class ships. It is integrated with the 56 sonar (Jane's Information Group, 2010).

## C. VARIANTS

The 89 system consists of 15 different variants. Variants differ based on the sensors chosen (19, 28, etc.) and the version of each sensor (53A, 53B, etc.). In this report, only variants 2, 3 4, 6, 7 and 9 were studied. These variants were chosen because the variants were on board ships prior to the introduction of CBT into the sonar training pipeline (2003) and remained on board after CBT was introduced. This allows for analysis of ship maintenance trends both prior to and after the introduction of CBT. A description of each variant follows and a list of ships per variant is given (Table 2).

### 1. AN/SQQ-89(v)2

For CG-47 class ships, (v)2 consists of the AN/SQR-19(v)1, AN/SQQ-28(v)3, AN/SQS-53B, AN/UYQ-25, and MK116.

For FFG-7 class ships, (v)2 consists of the AN/SQR-19(v)2, AN/SQQ-28(v)2, AN/SQS-56, AN/UYQ-25A, and WAP (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

### 2. AN/SQQ-89(v)3

The AN/SQQ-89(v)3 is available only on CG-47 class ships. It consists of the AN/SQR-19(v)1, AN/SQQ-28(v)3, AN/SQS-53B(v)2, AN/UYQ-25, and MK116 Mod 6 (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

### 3. AN/SQQ-89(v)4

The AN/SQQ-89(v)4 is available only on DDG-51 class ships. It consists of the AN/SQR-19A(v)4, AN/SQQ-28(v)3, AN/SQS-53C(v)1, AN/UYQ-25A(v)2, and MK116 Mod 7 (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

### 4. AN/SQQ-89(v)6

The (v)6 is available on CG-47 class and DDG-51 class ships. For CG-47 class ships, (v)6 consists of the AN/SQR-19B(v)1, AN/SQQ-28(v)9, AN/SQS-53C(v)1, AN/UYQ-25A(v)2, and MK116 Mod 7 (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

### 5. AN/SQQ-89(v)7

The (v)7 is available on CG-47 class ships and consists of the AN/SQR-19B(v)1, AN/SQQ-28(v)9, AN/SQS-53B(v)2, AN/UYQ-25B(v)2, and MK116 Mod 7 (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

### 6. AN/SQQ-89(v)9

The (v)9 is available on FFG-7 class ships and consists of the AN/SQR-19B(v)2, AN/SQQ-28(v)9, AN/SQS-56, AN/UYQ-25A(v)2, and WAP (Naval Sea Systems Command (NAVSEA), 1998, pp. G-5).

| (V)2 | SHIP | HOMEPORT |
|---|---|---|
| CG 55 | LEYTE GULF | Norfolk, VA |
| FFG 8 | MCINERNEY | Mayport, FL |
| FFG 28 | BOONE | Mayport, FL |
| FFG 29 | STEPHEN W GROVES | Mayport, FL |
| FFG 32 | JOHN HALL | Mayport, FL |
| FFG 33 | JARRET | San Diego, CA |
| FFG 36 | UNDERWOOD | Mayport, FL |
| FFG 38 | CURTS | San Diego, CA |
| FFG 39 | DOYLE | Mayport, FL |
| FFG 40 | HALYBURTON | Mayport, FL |
| FFG 41 | MCCLUSKY | San Diego, CA |
| FFG 42 | KLAKRING | Mayport, FL |
| FFG 43 | THACH | San Diego, CA |
| FFG 45 | DE WERT | Mayport, FL |
| FFG 46 | RENTZ | San Diego, CA |
| FFG 47 | NICHOLAS | Norfolk, VA |
| FFG 48 | VANDEGRIFT | San Diego, CA |
| FFG 49 | ROBERT G BRADLEY | Mayport, FL |
| FFG 53 | HAWES | Norfolk, VA |
| FFG 55 | ELROD | Norfolk, VA |
| FFG 56 | SIMPSON | Mayport, FL |
| FFG 57 | REUBEN JAMES | Pearl Harbor, HI |
| FFG 58 | SAMUEL B ROBERTS | Mayport, FL |
| FFG 59 | KAUFFMAN | Norfolk, VA |
| FFG 60 | RODNEY M. DAVIS | Everett, WA |
| FFG 61 | INGRAHAM | Everett, WA |

| (V)3 | SHIP | HOMEPORT |
|---|---|---|
| CG 56 | SAN JACINTO | Norfolk, VA |
| CG 57 | LAKE CHAMPLAIN | San Diego, CA |
| CG 58 | PHILIPPINE SEA | Mayport, FL |

| (V)4 | SHIP | HOMEPORT |
|---|---|---|
| DDG 51 | ARLEIGH BURKE | Norfolk, VA |

| (V)7 | SHIP | HOMEPORT |
|---|---|---|
| CG 66 | HUE CITY | Mayport, FL |
| CG 67 | SHILOH | Yokosuka, Japan |

| (V)9 | SHIP | HOMEPORT |
|---|---|---|
| FFG 37 | CROMMELIN | Pearl Harbor, HI |
| FFG 50 | TAYLOR | Mayport, FL |
| FFG 51 | GARY | San Diego, CA |
| FFG 52 | CARR | Norfolk, VA |
| FFG 54 | FORD | Everett, WA |

| (V)6 | SHIP | HOMEPORT |
|---|---|---|
| CG 68 | ANZIO | Norfolk, VA |
| CG 69 | VICKSBURG | Mayport, FL |
| CG 70 | LAKE ERIE | Pearl Harbor, HI |
| CG 71 | CAPE ST GEORGE | San Diego, CA |
| CG 72 | VELLA GULF | Norfolk, VA |
| DDG 52 | BARRY | Norfolk, VA |
| DDG 53 | JOHN PAUL JONES | San Diego, CA |
| DDG 54 | CURTIS WILBUR | Yokosuka, Japan |
| DDG 55 | STOUT | Norfolk, VA |
| DDG 56 | JOHN S. MCCAIN | Yokosuka, Japan |
| DDG 57 | MITSCHER | Norfolk, VA |
| DDG 58 | LABOON | Norfolk, VA |
| DDG 59 | RUSSELL | Pearl Harbor, HI |
| DDG 60 | PAUL HAMILTON | Pearl Harbor, HI |
| DDG 61 | RAMAGE | Norfolk, VA |
| DDG 63 | STETHEM | Yokosuka, Japan |
| DDG 64 | CARNEY | Mayport, FL |
| DDG 65 | BENFOLD | San Diego, CA |
| DDG 66 | GONZALEZ | Norfolk, VA |
| DDG 67 | COLE | Norfolk, VA |
| DDG 68 | THE SULLIVANS | San Diego, CA |
| DDG 69 | MILIUS | San Diego, CA |
| DDG 70 | HOPPER | Pearl Harbor, HI |
| DDG 71 | ROSS | Norfolk, VA |
| DDG 72 | MAHAN | Norfolk, VA |
| DDG 73 | DECATUR | San Diego, CA |
| DDG 74 | MCFAUL | Norfolk, VA |
| DDG 75 | DONALD COOK | Norfolk, VA |
| DDG 76 | HIGGINS | San Diego, CA |
| DDG 77 | O'KANE | Pearl Harbor, HI |
| DDG 78 | PORTER | Norfolk, VA |

Table 2. List of Ships and AN/SQQ-89(v) System Variants used in this study

## D. TRAINING

All STGs attend STG A school. At A school, students learn the basic principles of the STG rating including oceanography and principles of sound. Following A school, STGs are sent to different courses depending on whether they are operators or operator/maintainers. STGs that are strictly operators are sent to a Sonar Operator course, where they learn how to operate the specific 89 variant of the ship to which they will be sent. Maintainers are sent to C school, where they learn the technical skills required to maintain the equipment they will work on upon reporting to their ship. Operators and maintainers are assigned NECs based on the schools they attend (Navy Personnel Command, 2012). For example, an STG could be designated with the 0455 NEC, AN/SQQ-89(v)4/6 Active Sonar Level II Technician with the following job description:

> Performs organizational level maintenance on subsystems including; AN/SQS-53C Sonar System, AN/UQN-4/4A Sonar Sounding Set and the AN/WQC-2/2A Sonar Communications Set. Identify acoustic signatures to source. Operate the following subsystems; AN/SQQ-28(V) Sonar Signal Processing System, AN/SQS-19(V) TACTAS, AN/SQS-35C(V) 1/2/3 and AN/UYQ-25A(V)2 or AN/UYQ-25B SIMAS (Navy Personnel Command, 2012, p. 16 (Chapter 4)).

Data were not available to show how STG course lengths were affected by the conversion to CBT. The 2009 Navy IG report, *Computer Based Training*, examined the course lengths of 22 A and C schools for ILT and CBT. On average, CBT course lengths were 26% shorter than ILT course lengths (Naval Inspector General, 2009). This thesis will assume a 26% course length reduction for STG schools.

## E. SUMMARY

The 89 sonar system is an integrated set of sonar tools used in ASW. This study will examine the O&S costs of the 89 system and determine whether there is a relationship between the conversion to CBT in the STG rating and increased maintenance costs for the 89. The chapters that follow examine the methodology for examining the training and maintenance relationship and report the findings of the study.

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# VI. METHODOLOGY

## A. INTRODUCTION

The final question posed by this thesis was, "if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased O&M costs?" Attempting to answer this question at the macro level proved to be difficult because there appeared to be several variables that could impact Fleet maintenance costs such as OPTEMPO, Fleet manning, GWOT, maintenance policy changes, and the conversion to CBT. Data measuring training effectiveness were not available either pre- or post-CBT because there were no measurement standards in place. Navy budget data and O&S data were available for analysis, but the data available do not present an obvious answer; data had to be combined from several sources and, in some cases, assumptions and estimates of data had to be made in order to reach a conclusion. The sections that follow will describe the data sources used for the study of the AN/SQQ-89(v) sonar system and the methodology employed to organize, filter and clean the data (data normalization) for further analysis.

## B. DATA SOURCES AND ORGANIZATION

Data were collected from several DoD sources in order to determine the impact of the CBT conversion in the STG rating on maintenance in the fleet. PEO IWS5 provided a list of ships equipped with the AN/SQQ-89(v) sonar system. Naval Personnel Command (NPC) provided STG manning data for CG-47, DDG-51, and FFG-7 class ships. Navy Visibility and Management of Operating and Support Costs (VAMOSC) provided O&S cost data, underway steaming days, and selected non-cost data for ships equipped with the AN/SQQ-89 sonar system.

CBT was introduced full-time into the training pipeline in FY2003, after the recommendations of the ERNT report (Naval Inspector General, 2009). This study focuses on FYs 1999 through 2010 to capture data prior to and after the introduction of

CBT. Initially, FYs 1995 through 1998 were also considered, but there were not enough data available during this timeframe for most data categories. The raw data provided were analyzed to reveal relationships between selected data sets.

### 1. Order of Battle (OOB)

PEO IWS 5 provided a list of ships equipped with the 89 system. The list included ship class, ship name, hull number, homeport, and 89 variant number. Only ships with AN/SQQ-89(v) variants on board both prior to and after introduction of CBT into the STG rate training pipeline were considered. The initial list provided by PEO IWS5 included all ships of the CG-47, DD-963, DDG-51, and FFG-7 classes. To narrow the ship list to match the scope of our study, ships were removed from the data set if:

- The ship was decommissioned during the FY95-06 timeframe
- The ship received a variant upgrade
- The ship was commissioned FY2000 or later
- The ship was outfitted with a variant introduced after FY03

Using the above criteria, the ship list was reduced to 68 ships. All *Spruance* (DD-963) class ships were removed due to decommissioning. Only ships with (v)2, 3, 4, 6, 7, or 9 were considered since they existed both prior to and after the introduction of CBT. Additionally, several ships of the FFG-7 and CG-47 classes decommissioned and several CG-47 class ships received variant upgrades. USS ANTIETAM (CG 54) was eliminated because data reporting stopped in 2004. The final list of 68 ships was separated by variant and includes homeport (Table 2, Chapter V.C).

### 2. NPC Manning Data

STG manning data were analyzed to determine whether STG manning levels were an important variable in the study since the Balisle report included the shift to optimal manning as a contributor to degraded Fleet readiness. Manning data provided by NPC initially included manning numbers for all ratings on board the ships of the CG 47, DDG 51, and FFG 7 classes. The following data points were given for each fiscal year for all ships of the CG-46, DDG-51, and FFG-7 classes (sample provided in Table 3):

- Billets Authorized (BA) for pay grades E1-E3, E4, E5, E6, E7, E8 and E9
- Navy Manning Plan (NMP) for pay grades E1-E3, E4, E5, E6, E7, E8 and E9
- Current On Board (COB) for pay grades E1-E3, E4, E5, E6, E7, E8 and E9

BA refers to “a funded military manpower space, which has been authorized by CNO (Department of the Navy, 2003, p. 1).” NMPs are used by NPC to determine the ‘fair share’ of personnel from a particular rating which are distributed from the personnel inventory to a particular ship (Department of Defense Inspector General, 2004). COB refers to the number of personnel on board a given ship in a particular rating.

| (v)3 | UIC | HULL NO. | SHIP NAME | RATE | Billets Authorized (BA) | BA E1-E3 | BA E4 | BA E5 | BA E6 |
|---|---|---|---|---|---|---|---|---|---|
| | 21389 | CG 56 | SAN JACINTO | STG | 16 | 1 | 6 | 5 | 3 |
| | 21428 | CG 57 | LAKE CHAMPLAIN | STG | 16 | 3 | 6 | 4 | 2 |
| | 21429 | CG 58 | PHILIPPINE SEA | STG | 16 | 1 | 7 | 4 | 3 |

Table 3. Sample Manning Data - FY99 BA for (v)3 (Navy Personnel Command)

The data were filtered to include only the STG rating and the ships selected in Table 1. A variant manning average (VMA) was determined for each variant in a FY to show the average manning levels for the STG rating on a particular AN/SQQ-89(v) variant in the selected FY. This allowed for trend detection for each variant to note whether manning for a particular variant was changing from year-to-year. For variants installed on multiple ship classes, separate VMAs were calculated for each class of ship. For example, (v)2 was installed on ships of the CG-47 and FFG-7 classes, so VMAs were calculated separately for each class (Table 4).

| (v)6 | UIC | HULL NO. | SHIP NAME | RATE | Billets Authorized (BA) | BA E1-E3 | BA E4 | BA E5 | BA E6 |
|---|---|---|---|---|---|---|---|---|---|
| | 21658 | CG 68 | ANZIO | STG | 16 | 1 | 7 | 4 | 3 |
| | 21684 | CG 69 | VICKSBURG | STG | 16 | 1 | 7 | 4 | 3 |
| | 21827 | CG 70 | LAKE ERIE | STG | 18 | 3 | 7 | 4 | 3 |
| | 21828 | CG 71 | CAPE ST GEORGE | STG | 16 | 1 | 7 | 4 | 3 |
| | 21829 | CG 72 | VELLA GULF | STG | 16 | 1 | 7 | 4 | 3 |
| (v)6 CG AVG | | | | | 16.4 | 1.4 | 7 | 4 | 3 |

Table 4. Sample Manning Data with VMA (Full data set not shown) (Navy Personnel Command)

### 3. Visibility and Management of Operating and Support Costs (VAMOSC)

Navy VAMOSC provided a database of O&S costs for the AN/SQQ-89(v) system covering FYs 1995 through 2010. The O&S data given were a line-by-line description of all costs associated with the 89 system. Non-cost data such as manhours and number of corrective maintenance actions were also given. Cost figures were given in then-year and constant FY2 011 dollars. In addition to the overall 89 system data, detailed ship data were also given for the selected ships. Detailed ship data did not include training costs, which had to be estimated (description of estimation techniques is discussed later in the report). O&S costs for individual ships carrying the 89 system were analyzed to determine the relationship between training and maintenance. Definitions of key O&S terms used in this study are listed in Appendix A. Since this study focuses on training and maintenance, not all O&S data points provided by VAMOSC were relevant. Table 5 shows the O&S data points used for this study.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | Direct Unit Cost | 1.2 | Unit Level Consumption | 1.2.2 | Repair Parts & Repairables | 1.2.2.2 | Repair Parts - Organizational Repair Parts | | | | |
| 1.0 | Direct Unit Cost | 1.2 | Unit Level Consumption | 1.2.2 | Repair Parts & Repairables | 1.2.2.3 | Repairables | 1.2.2.3.1 | Replenishr | 1.2.2.3.1.1 | Replenishment Spares (Iss |
| 1.0 | Direct Unit Cost | 1.2 | Unit Level Consumption | 1.2.2 | Repair Parts & Repairables | 1.2.2.3 | Repairables | 1.2.2.3.1 | Replenishr | 1.2.2.3.1.2 | Replenishment Spares (Iss |
| 1.0 | Direct Unit Cost | 1.2 | Unit Level Consumption | 1.2.2 | Repair Parts & Repairables | 1.2.2.3 | Repairables | 1.2.2.3.2 | Exchanges - LOGCEN | | |
| 2.0 | Maintenance - Intermediate | 2.1 | Labor - Intermediate Maintenance | 2.1.1 | Labor - Afloat Intermediate Maintenance | | | | | | |
| 2.0 | Maintenance - Intermediate | 2.1 | Labor - Intermediate Maintenance | 2.1.2 | Labor - Ashore Intermediate Maintenance | | | | | | |
| 2.0 | Maintenance - Intermediate | 2.2 | Material - Intermediate Maintenance | 2.2.1 | Material - Afloat Repair Parts Intermediate Maintenance | | | | | | |
| 2.0 | Maintenance - Intermediate | 2.2 | Material - Intermediate Maintenance | 2.2.2 | Material - Ashore Repair Parts Intermediate Maintenance | | | | | | |
| 3.0 | Maintenance & Modernization | 3.6 | Equipment Rework | 3.6.4 | Equipment Rework - Contractor - Program Office | | | | | | |
| 3.0 | Maintenance & Modernization | 3.6 | Equipment Rework | 3.6.5 | Equipment Rework - Government - Program Office | | | | | | |
| 3.0 | Maintenance & Modernization | 3.9 | Other Depot | 3.9.1 | Maintenance - Depot - Public Shipyards - Systems | | | | | | |
| 3.0 | Maintenance & Modernization | 3.9 | Other Depot | 3.9.2 | Maintenance - Depot - Private Shipyards - Systems | | | | | | |
| 4.0 | Other Operating & Support | 4.1 | Training | 4.1.1 | Training - Program Office | | | | | | |
| 4.0 | Other Operating & Support | 4.1 | Training | 4.1.2 | Training - NETPDTC | | | | | | |
| 4.0 | Other Operating & Support | 4.3 | Engineering & Technical Services (ETS) | 4.3.3 | Engineering & Technical Services (ETS) - Program Office | | | | | | |
| A.0 | Number of Ships or Number of Systems | | | | | | | | | | |
| D.0 | Personnel Trained | D.1 | Personnel Trained - Program Office | | | | | | | | |
| D.0 | Personnel Trained | D.2 | Personnel Trained - NETPDTC | | | | | | | | |
| D.0 | Personnel Trained | | | | | | | | | | |
| G.0 | Manhours - Org Corrective Maint | | | | | | | | | | |
| H.0 | Manhours - Intermediate Maint | H.1 | Manhours - Intermediate Maintenance - Afloat | | | | | | | | |
| H.0 | Manhours - Intermediate Maint | H.2 | Manhours - Intermediate Maintenance - Ashore | | | | | | | | |
| I.0 | Number of Corrective Maintenance Actions - O&I Level | | | | | | | | | | |
| J.0 | Manhours - Depot Maintenance - Public | | | | | | | | | | |

Table 5. O&S Data Points (Navy VAMOSC)

All O&S data were analyzed using constant FY11 dollars. All fields were summed to yield a total O&S cost for each FY. All data fields relevant to training and maintenance study, including non-cost data points such as personnel trained and man-hours were analyzed further.

Navy VAMOSC also provided detailed ship O&S data and ship underway days for analysis. Underway days were studied to determine whether OPTEMPO was related to number of maintenance actions or maintenance cost. Detailed ship O&S data were used to analyze ship-to-ship trends and determine whether variant, homeport, or ship class were significant factors. For each data set, only ships with complete or near-complete data were selected. Near-complete is defined as no more than 3 years of missing data. Due to inconsistencies in data reporting, some data sets had larger sample sizes than others. There were not sufficient data present for any ship to analyze the following data sets:

- Labor – Afloat Intermediate Maintenance Manhours
- Materials – Afloat Repair Parts Intermediate Maintenance Cost
- Materials – Ashore Repair Parts Intermediate Maintenance Cost
- Replenishment Spares – Logistic Center (LOGCEN) Cost

## C. CONSOLIDATED DATA TABLE

After filtering and normalizing the raw data in OOB, 89 Sonar System data, personnel data, and detailed ship O&S Cost, the data were consolidated into a single file for further analysis. Detailed ship O&S cost data were used instead of the overall O&S cost data for the 89 system because the detailed ship data provided more granularity and allowed for trend detection from ship to ship. The consolidated file is listed by fiscal year and includes a data separator to separate pre- and post-CBT years. Ships are identified by class, hull number and ship name. For each ship, 89 variant, 89 install year, homeport, E1-E6 STG manning, underway days, and VAMOSC O&S data are given.

All maintenance data provided by Navy VAMOSC were given in a detailed ship file. Additionally, Navy VAMOSC provided overall AN/SQQ-89 O&S data that represented all U.S. Navy ships that had an AN/SQQ-89 sonar system installed. Since ship-specific training and O&S data were not provided, they were estimated and allocated to each ship using methodology described in the paragraphs to follow.

The quantity of 89 systems and ships in operation is given for each fiscal year in the O&S data. Using information provided by Program Executive Office Integrated warfare System (PEO IWS) 5, the number of ships per class for each fiscal year was determined. Ships are separated by class in order to allocate training and O&S data to each ship based on average manning levels for each ship class.

Manning data provided by NPC were used to estimate the average number of STG personnel per ship class. The number of STG personnel for each fiscal year was determined by multiplying the number of ships in a class by the average manning number for that class, and summing each ship class manning number together.

The average cost per STG personnel was determined by dividing Training – Naval Education and Training Professional Development and Technology Center (NETPDC) and O&S (Total) by the number of personnel for each fiscal year. Training and O&S cost for each ship was determined by multiplying the average cost per STG by the average number of STG per ship class. Using this method, Training and O&S costs for each ship in a particular class are identical (based on an average). In reality, this is not the case, but given the lack of detailed ship information for these data points, this estimation method represents a reasonable way to allocate detailed Training and O&S data to individual ships.

Data in the consolidated data matrix were cleaned by removing outliers. Approximately 1% of all data points collected were outliers. Outliers were determined to be any data point that exceeded plus or minus three standard deviations from the mean. The method for determining outliers is described in the paragraphs to follow.

Pivot tables were constructed with Hull Number as the row field and Fiscal Year as the column field. Data were populated into this format for manning, underway days, and selected VAMOSC data. Outliers were determined by using conditional formatting to identify which data points laid plus or minus three standard deviations from the mean.

The highlighted data points were removed and the remaining data were placed into a "cleaned data" file. The final consolidated data file was used to conduct analysis to determine the relationship between the introduction of CBT and maintenance on the AN/SQQ-89(v) system.

The consolidated data file represents all data deemed relevant to studying the relationship between the conversion to CBT and increased maintenance costs in the 89 sonar system. All data contained in the consolidated file were analyzed to determine an answer to the final question posed in the thesis, "if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased O&M costs?" The results of this analysis are discussed in the next chapter.

## D. SUMMARY

Data were collected from several Navy sources in order to answer the final thesis question. The data represented both cost and non-cost elements that were deemed essential to answering the question. Relevant data was assembled into a consolidated data file for analysis. Results of this analysis are given in Chapter VII, Results.

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# VII. RESULTS

## A. ANALYSIS

The data collected from NPC, PEO IWS5 and VAMOSC were collected into a consolidated data file in order to answer the final thesis question, “if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased O&M costs?” Data was analyzed using methods including graphical analysis, single-factor regression analysis, and paired t-tests to determine answer to the final thesis question. Further explanation of the methods used in this study, and results, are discussed in this chapter.

### 1. NPC Manning Data

For each variant, variant moving averages (VMAs) for FY99 through FY10 were tabulated and plotted to determine if there were significant changes in manning from year to year. In the Navy maintenance community, pay grades E1 through E6 perform the bulk of preventative and corrective maintenance actions. Only pay grades E1 through E6 were studied for manning level changes (Figure 6). In this example, there do not appear to be any noticeable manning trends. For (v)2 CGs, Billets Authorized (BA) remained constant across all fiscal years, while Navy Manning Plan (NMP) and Current On Board (COB) had variability. COB is the most telling of the three measures of manning because it shows the actual number of STG personnel on board vice a prescribed amount. In this case, manning was highly variable from year to year and does not appear to be tied to the reduced (optimal) manning concept. The variability in manning for COB may be attributed to the early departure of sailors for disciplinary reasons or the acquisition of additional sailors due to cross-rating from one job to another. In Figure 6, for example, the VMAs in FYs 2003 and 2004 show a great deal of variance which may be attributed to the previously noted personnel issues. The example given in Figure 6 is consistent through all variants of the 89 system; that is, all variants of the 89 system show stable BA manning numbers and variable COB numbers. There does not appear to be a trend towards reduced manning in the STG rate from a variant standpoint.

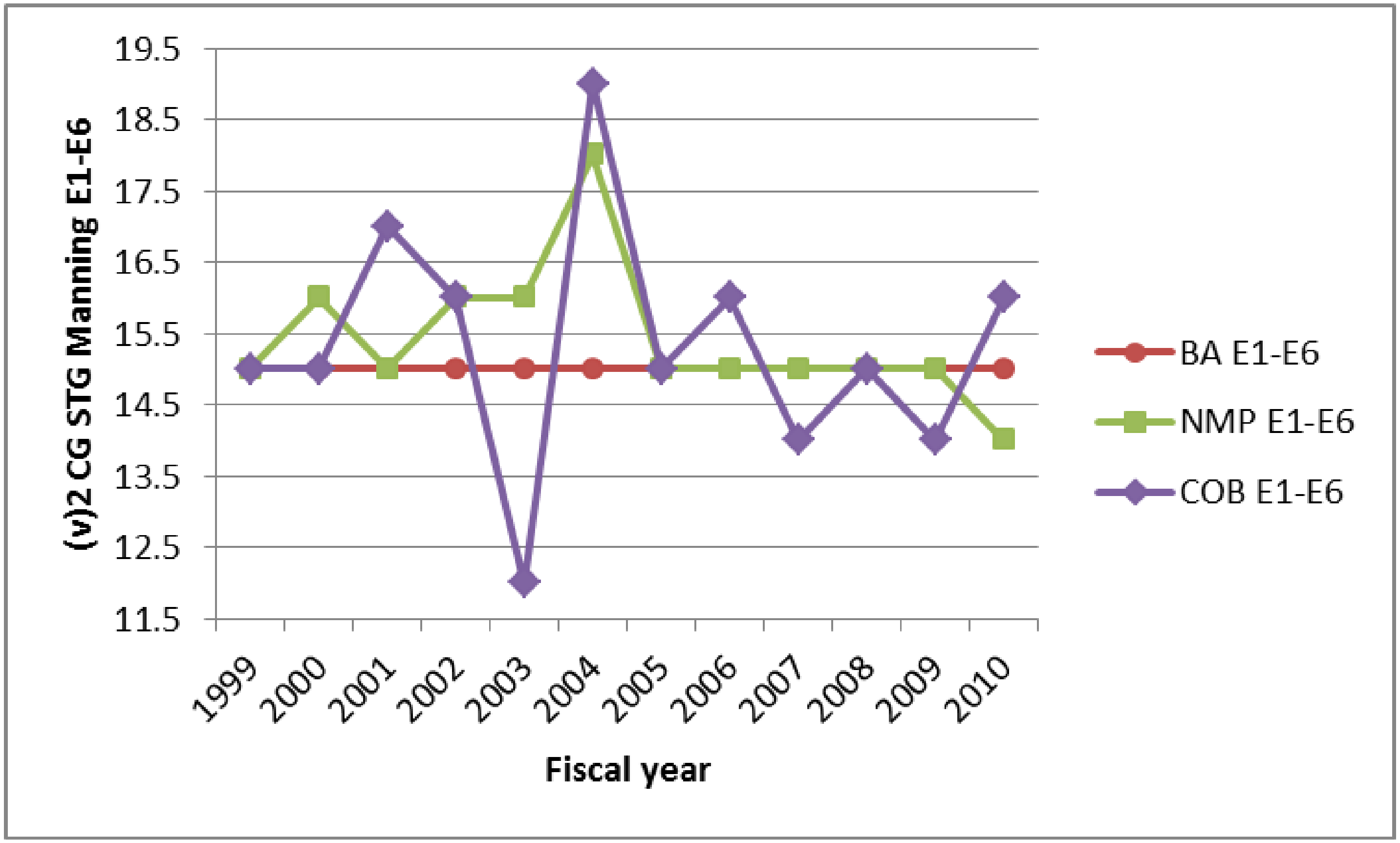


Figure 6. (v)2 STG Manning FYs 1999–2010

VMAs for ship class (CG-47, DDG-51, FFG-7), regardless of variant, were also plotted to determine whether there were any significant changes in manning for each class of ship for FY99 through FY10 (Figure 7). As with VMA's per variant, the VMA per ship class was fairly stable when observing BA and more variable with NMP and COB. Again, the VMA for COB was highly variable, but it tended to be higher than the VMA for BA and it does not appear that the STG rating was significantly affected by the optimal manning concept. The example provided in Figure 7 is indicative of the trends exhibited by all ship classes studied; that is, DDG-51 and FFG-7 class ships also showed relatively stable BA manning numbers and variable COB numbers. There was no noticeable trend towards reduced manning in the STG rating from a ship class perspective.

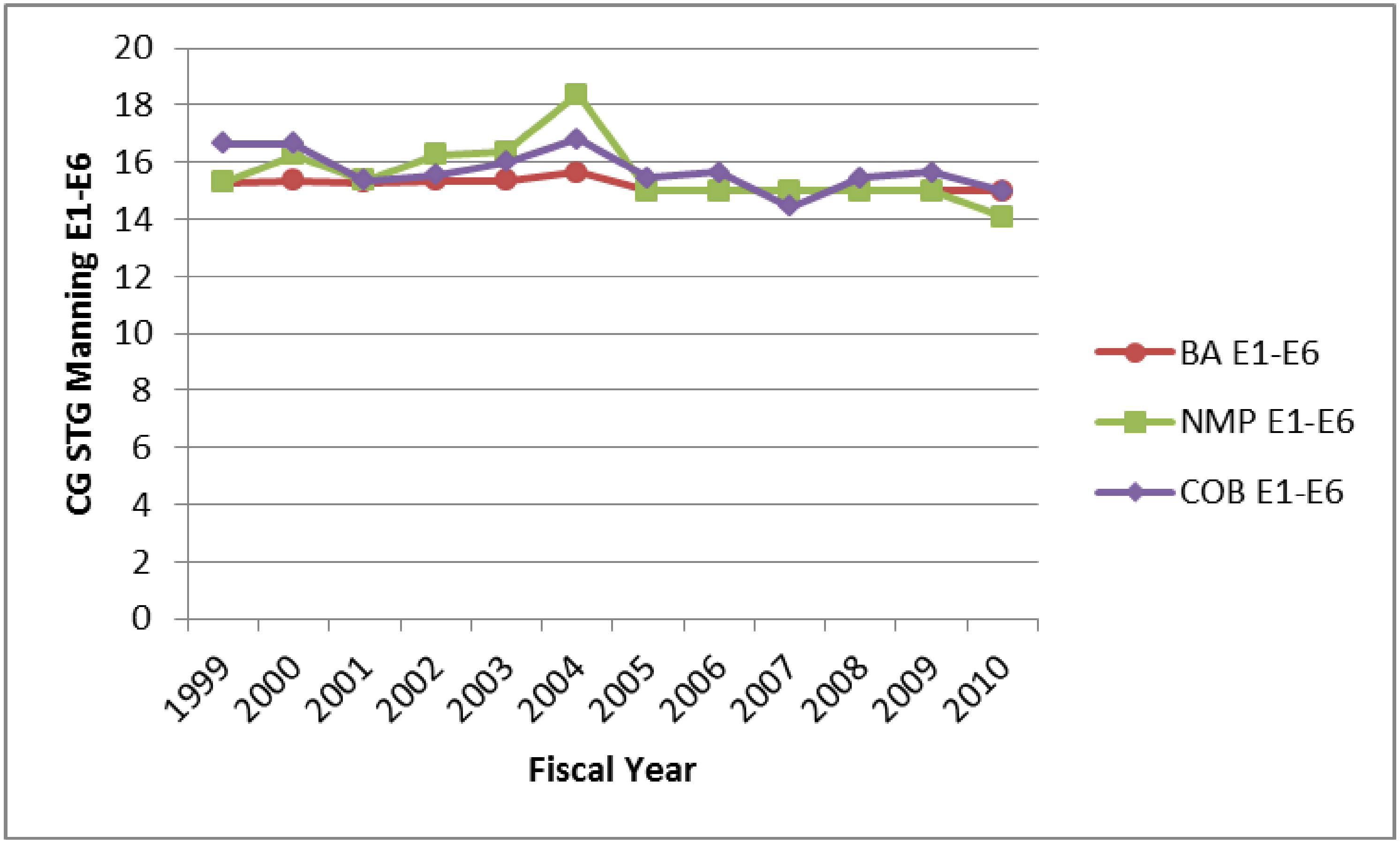


Figure 7. CG Class STG Manning, FYs 1999–2010

As Figures 6 and 7 indicate, whether analyzing the data from the variant perspective or from the ship class perspective, manning may not have a significant impact on the study. Across all variants, BA remains relatively consistent through the FYs. In all cases, the VMA for BA changed by less than 1, with the exception of FFG manning, which decreased by 2 in FY2009. NMP and BA were more variable, but the variability was observed from year-to-year and it does not appear that optimal manning in the Fleet impacted the STG rating as much as it may have affected other ratings. For this reason, manning was not considered to be a significant factor in drawing a conclusion to the proposed thesis question.

### 2. VAMOSC

For the overall 89 system O&S components selected for this study, calculations were made to determine what percentage each component was of total O&S costs. This was done to determine spending changes for a particular component from year-to-year (Table 6).

| | 1995 | 1996 | 1997 |
|---|---|---|---|
| **Unit Level Consumption as % of O&S** | 7.57% | 5.21% | 15.68% |
| **Intermediate Maintenance as % of O&S** | 0.08% | 0.03% | 0.34% |
| **Equipment RE-work as % of O&S** | 1.05% | 0.06% | 1.31% |
| **Depot Maintenance as % of O&S** | 0.00% | 0.07% | 0.00% |
| **Training (Program Office) as % of O&S** | 0.00% | 0.00% | 0.00% |
| **Training (NETPDTC) as % of Program Office** | 12.40% | 13.55% | 45.54% |
| **Training (Total) as % of O&S** | 12.40% | 13.55% | 45.54% |
| **Engineering and Technical Support as % of O&S** | 20.69% | 4.95% | 8.24% |
| **Software Support as % of O&S** | 10.92% | 1.46% | 4.52% |
| **Training Cost (Total)** | $ 8,343,490 | $ 10,704,760 | $ 19,250,317 |
| **Unit Level Consumption Cost (Total)** | $ 5,094,929 | $ 4,118,052 | $ 6,628,471 |
| **Intermediate Maintenance Cost (Total)** | $ 50,565 | $ 20,681 | $ 143,961 |
| **Equipment Rework Cost (Total)** | $ 704,760 | $ 46,567 | $ 555,816 |
| **Depot Maintenance Cost (Total)** | $ - | $ 52,075 | $ - |

Table 6. Sample O&S Calculations

After components were analyzed as a percentage of overall cost, each component was analyzed for changes in dollars spent. This was done because it is possible that though the percentage in relationship to the overall whole may have changed, the actual dollar amount spent on a particular component didn't change at all due to spending changes in other areas. If the dollar amount is relatively unchanged in the case of training costs, it would suggest that the claims of cost savings were inaccurate. To illustrate this, Figures 8 and 9 show the relationships for Training (Total) and IM.

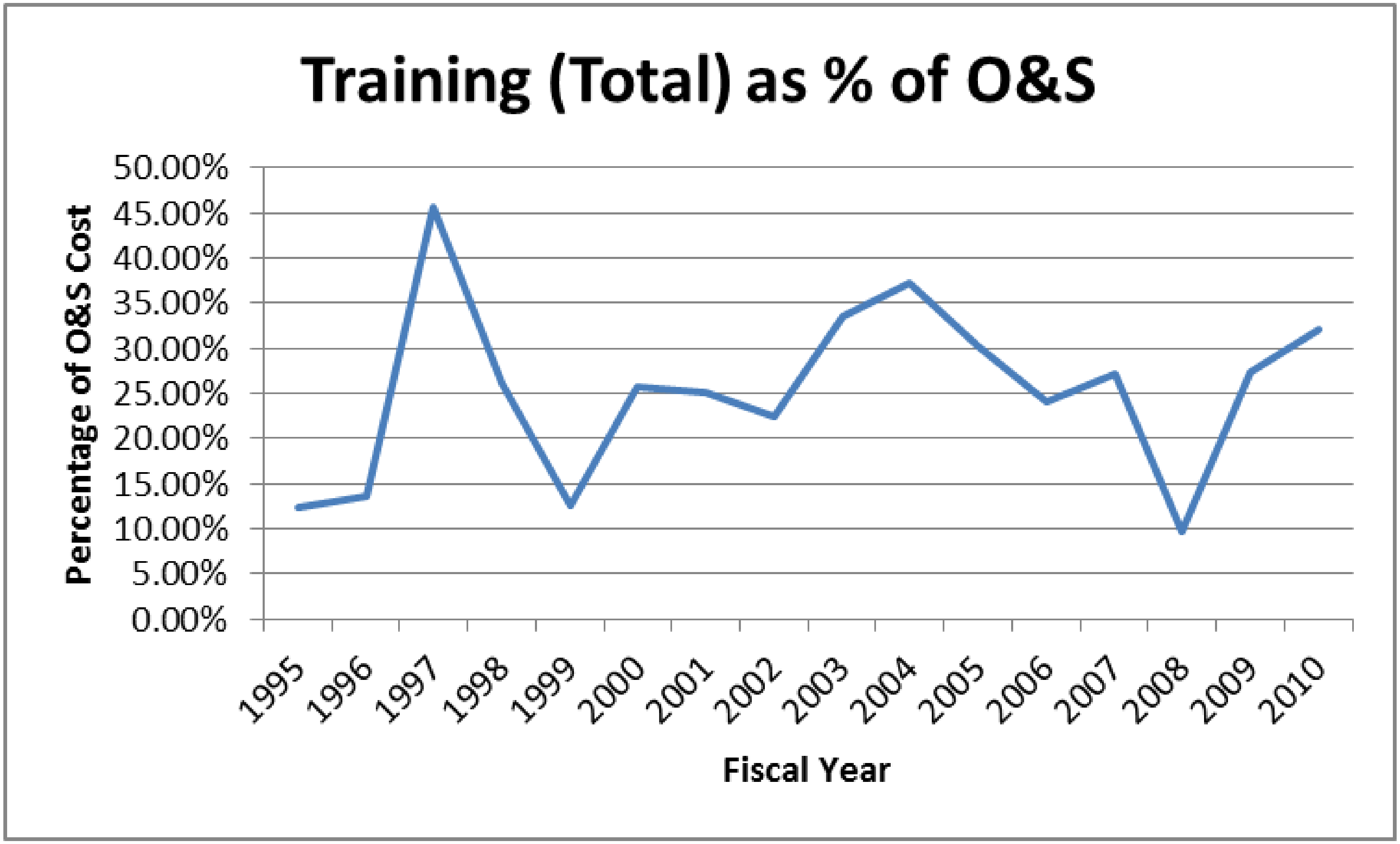


Figure 8. Training (Total) as Percentage of O&S Costs

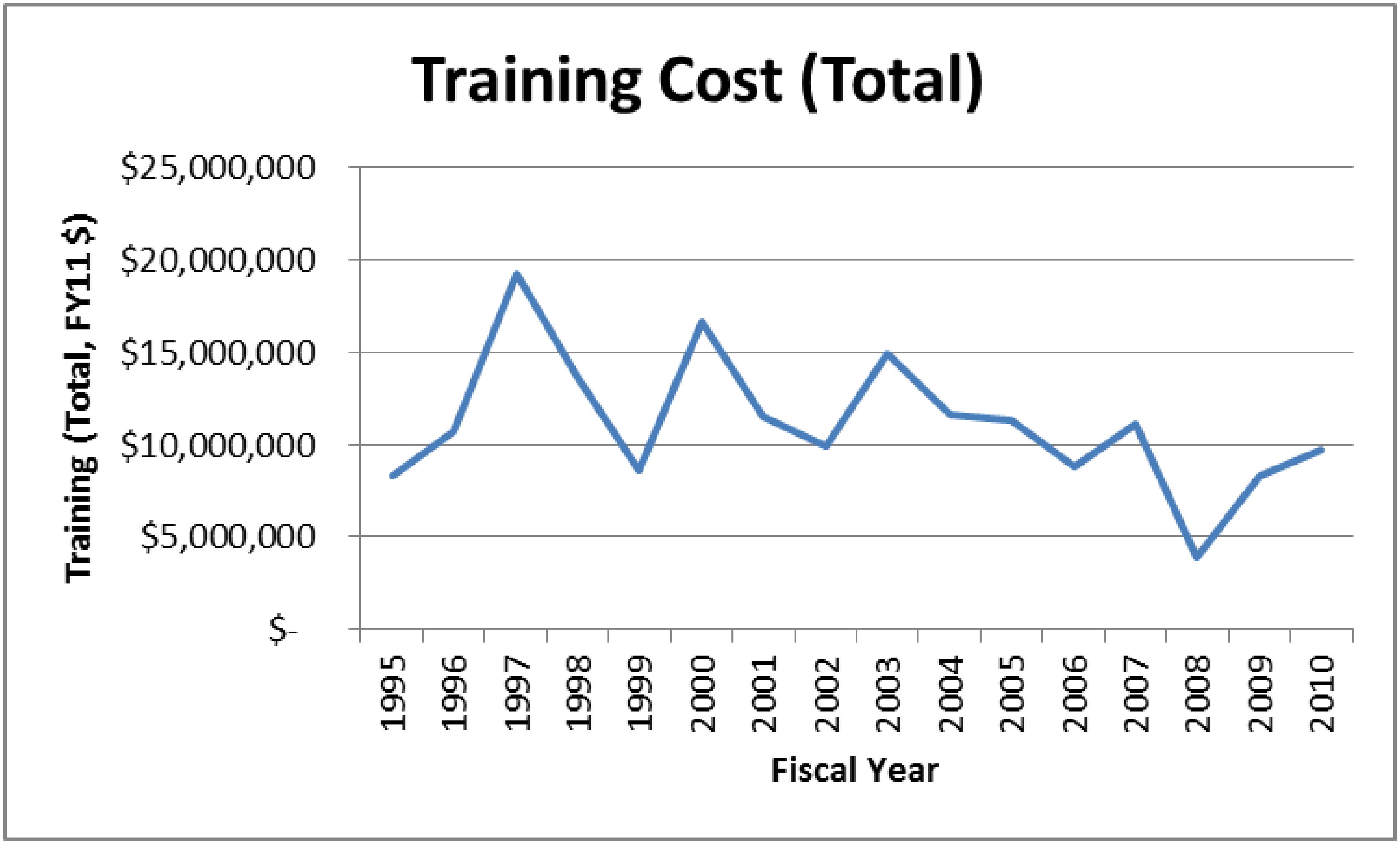


Figure 9. Training Cost

Figures 8 and 9 show that over the same time period, training as a percentage of total O&S costs behaved similarly, but not identically, to overall training costs. Generally, it appears that training costs were lower for the 89 system after the introduction of CBT, which suggests that the claims of cost savings when converting to CBT were accurate in terms of the 89 system.

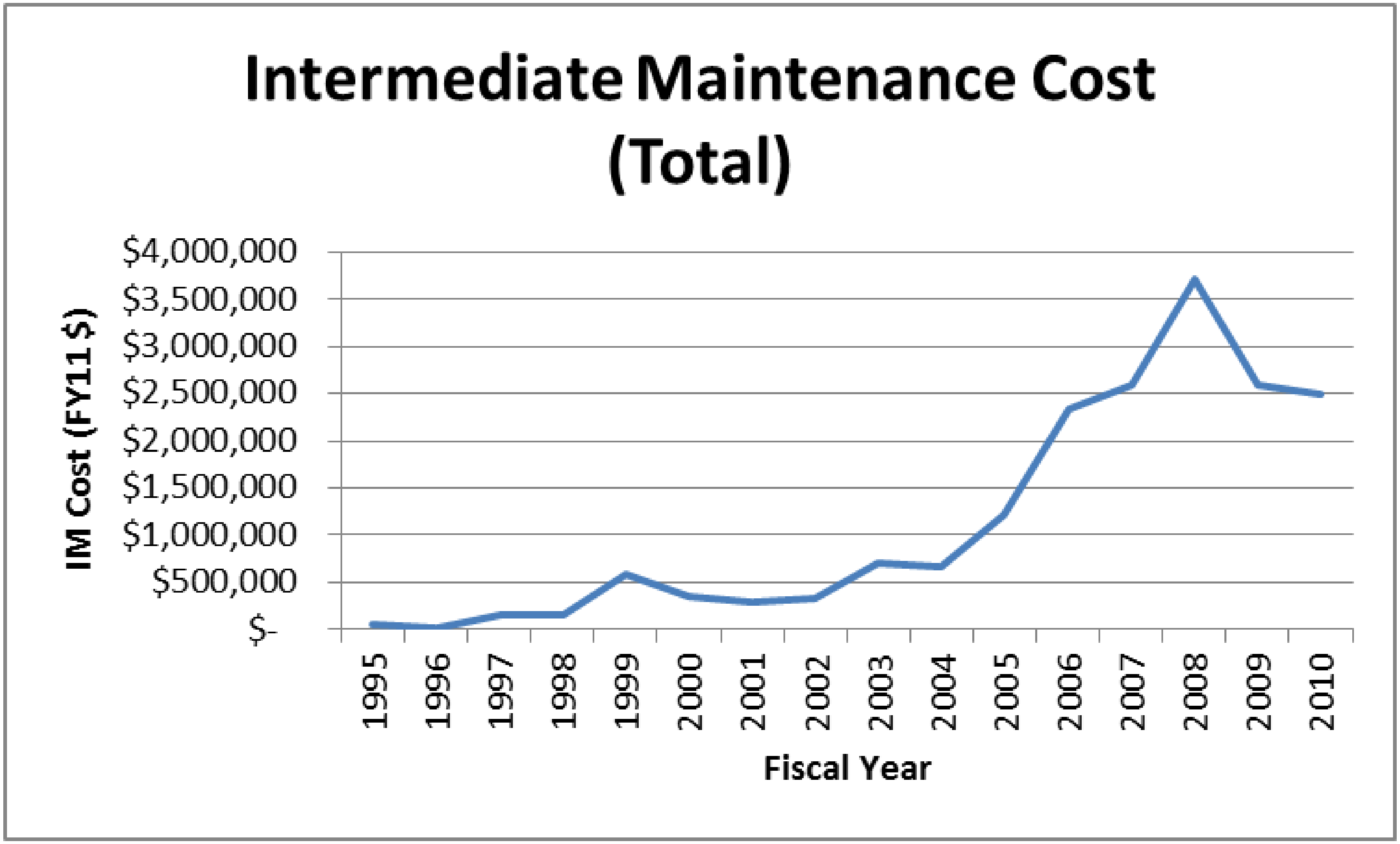


Figure 10. Intermediate Maintenance Cost

Figure 10 shows that IM costs increased substantially after the introduction of CBT (2003). While IM costs were trending upward prior to 2003, the rapid rise in costs after 2003 suggests that there is cause to further analyze the relationship between decreasing training costs and increased maintenance costs.

Non-cost data were also provided and included number of personnel trained, maintenance manhours, and number of maintenance actions. The data were used to calculate average time (in manhours) spent per maintenance action, cost to train (per person) using Program Office dollars, and cost to train (per person) using NETPDTC dollars. These numbers were calculated to determine training and maintenance trends pre- and post-CBT. For instance, if the average time spent per maintenance action increased, it could suggest a backlog of maintenance or a lack of technical competence in performing a maintenance action. Since number of personnel trained for the Program Office and NETPDTC were unavailable for some FYs, the cost to train data were not useful. Manhours spent per maintenance action, however, were useful (Figure 11). Prior to CBT, manhours spent per maintenance action were trending upward; after the introduction of CBT, manhours per maintenance action remained relatively flat. This suggests that manhours per maintenance action may have reacted positively to the conversion to CBT; however, this assumes that the types of maintenance actions perform remained relatively constant.

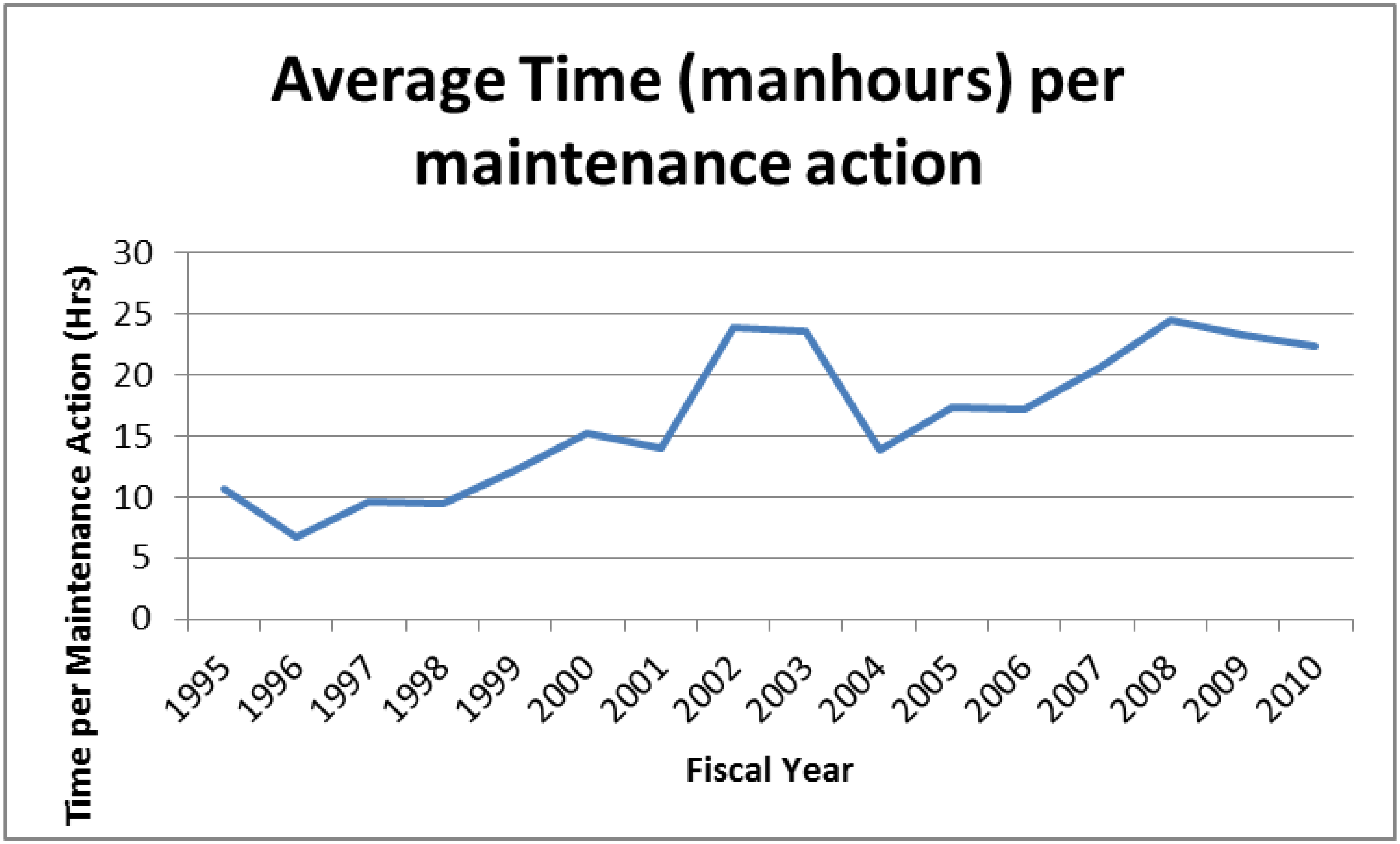


Figure 11. Man-hours Spent per Maintenance Action

Single-factor regression analysis was performed to explore the relationship between total training cost and the O&S variables provided by Navy VAMOSC. Unit Level Consumption, IM, Equipment Rework, and Depot Maintenance were selected as variables to determine whether changes in training costs resulted in increased maintenance costs. The selected variables represent organizational, intermediate, and depot level maintenance. Unit Level Consumption is a summation of Organizational Repair Parts, Replenishment Spares, and Logistics Center (LOGCEN) exchanges. Equipment Rework is a summation of contractor and government Program Office rework costs. IM is a summation of afloat and ashore IM labor costs and ashore IM materials costs. Depot Maintenance is a summation of private and public shipyard depot costs. Training (Total) is a summation of Program Office and NETPDTC training costs.

| | $R^2$ |
|---|---|
| Unit Level Consumption | 0.033 |
| Equipment Rework | 0.002 |
| Intermediate Maintenance | 0.348 |
| Depot Level Maintenance | 0.208 |

Table 7. Regression Analysis - O&S Components

$R^2$ measures the percentage of variation in a response variable that is explained by the interaction with a predictor variable. An $R^2$ value greater than .70 would indicate a significant relationship between the factors. In this case, regression analysis shows that none of the factors selected show a statistically significant relationship to total training cost. The scatter plots shown in Figures 12–15 illustrate the general relationship between each of the maintenance categories and training costs. For each maintenance category the best-fit line (based on ordinary least squares regression) is drawn and the equation of the line, as well as the $R^2$ is shown. The closer the points on the plot are to the fitted line, the higher the correlation between the two variables. If the points are scattered all over the graph with no apparent pattern, then no relationship is suggested by the plot and further analysis will likely prove fruitless. The relationships may be positive or negative depending on the slope of the line. A slope of zero indicates no relationship. The first two plots (Figures 12 & 13) suggest that there is no relationship between training costs and unit level consumption or equipment rework. The Intermediate Maintenance (IM) scatter plot (Figure 14) suggests that there may be a relationship between training costs and intermediate maintenance and warrants further investigation. Specifically the plot suggests that as training costs increase, intermediate maintenance costs decrease. This would support the hypothesis that when less money is spent on training (as a result of switching to CBT) the maintenance costs will increase. The final plot (Figure 15) appears to have an outlier that skews the relationship. Without this data point, there does not appear to be a strong relationship between depot maintenance and training costs. Overall, the regression analysis suggests that if maintenance variables have a correlated relationship with training in the STG rating, there are other factors not identified in this study that are having an effect.

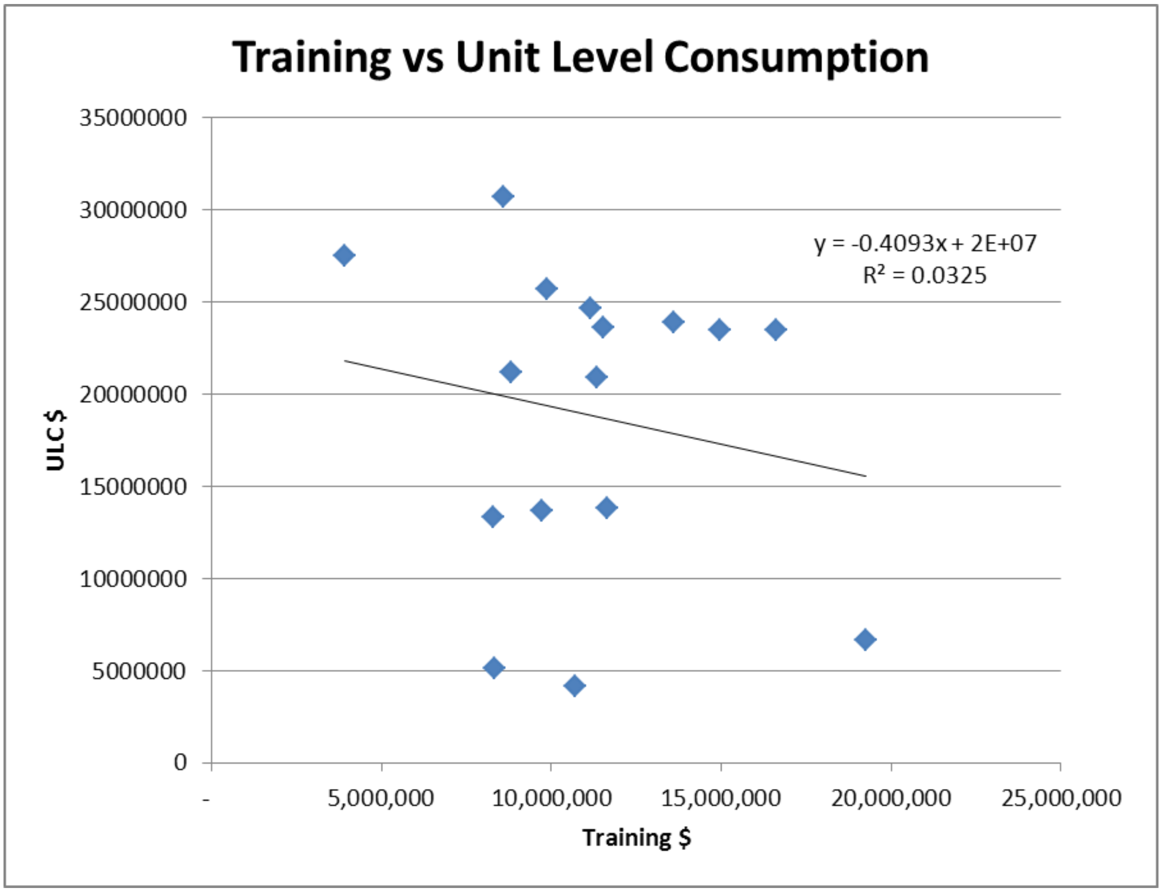


Figure 12. Training vs. Unit Level Consumption Scatter Plot

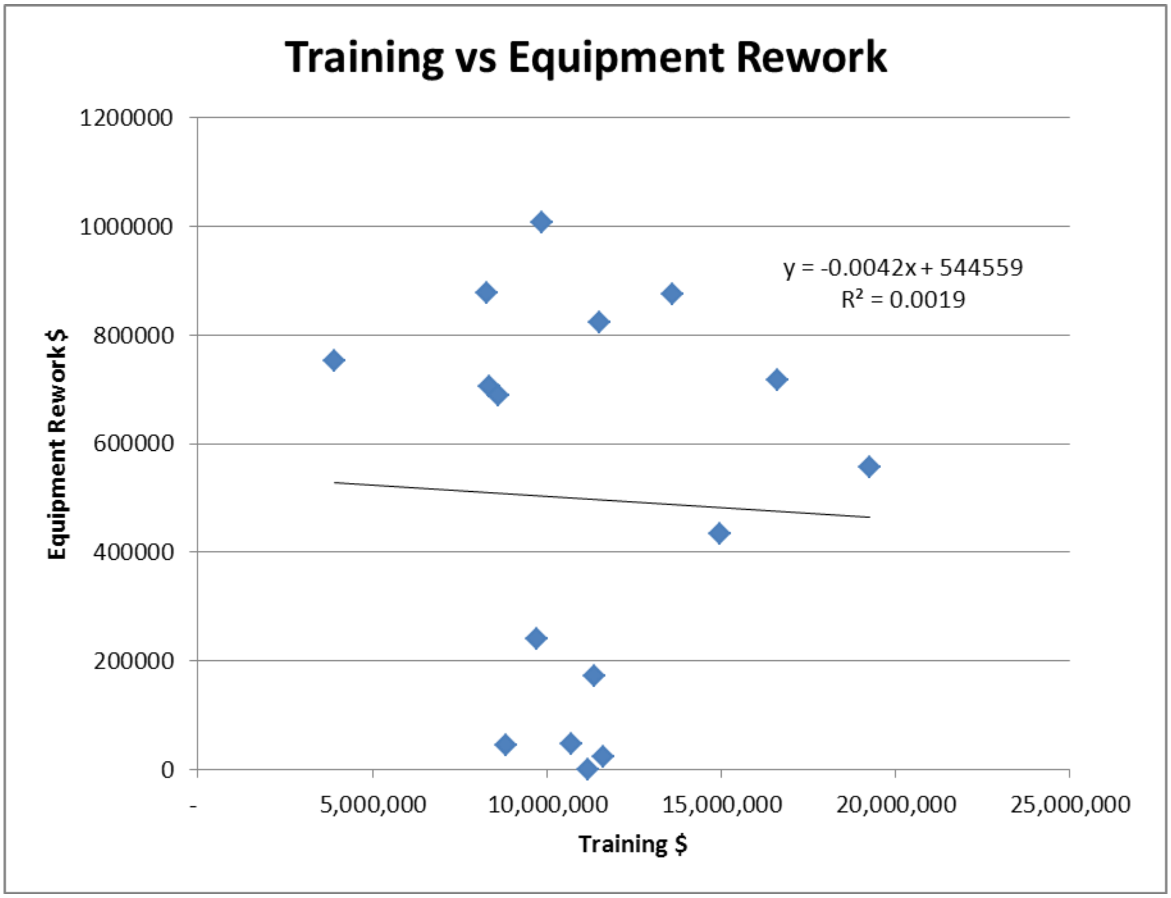


Figure 13. Training vs. Equipment Rework Scatter Plot

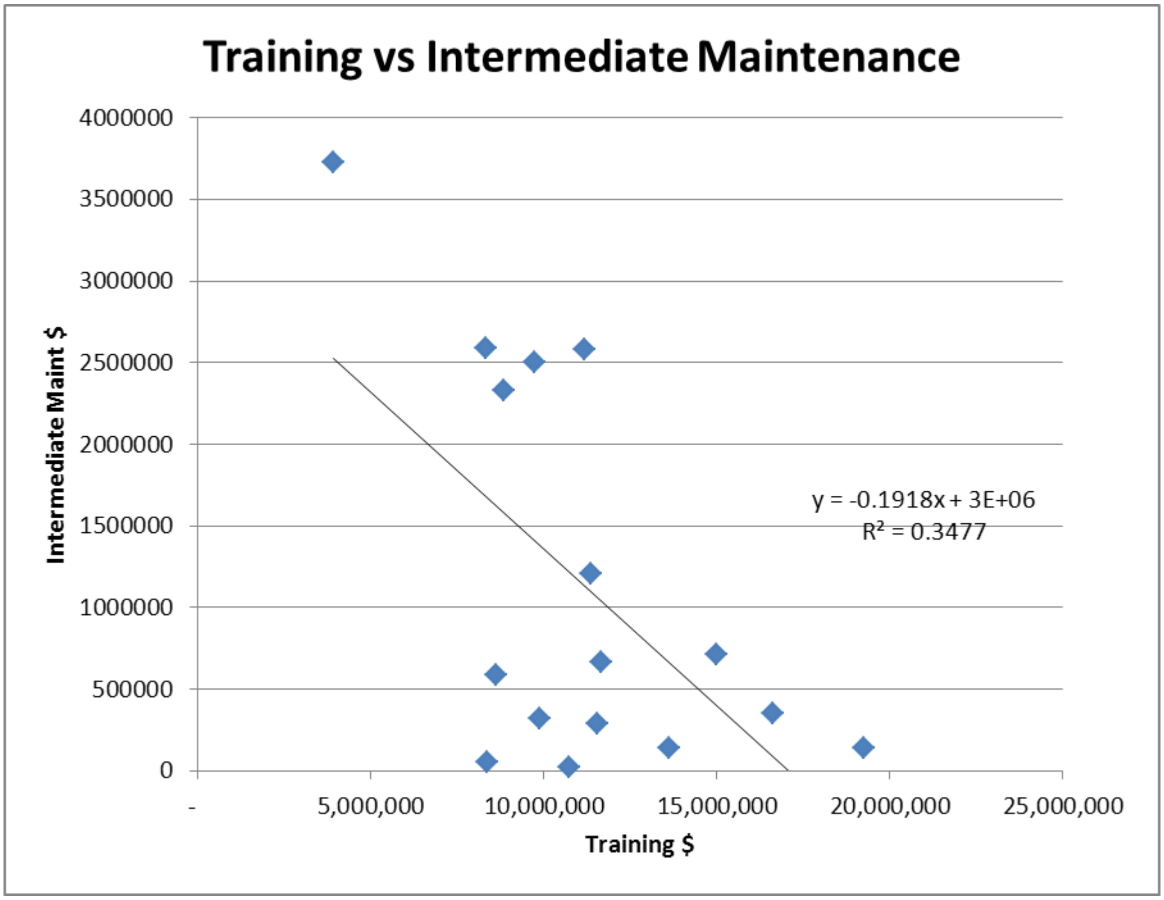


Figure 14. Training vs. Intermediate Maintenance Scatter Plot

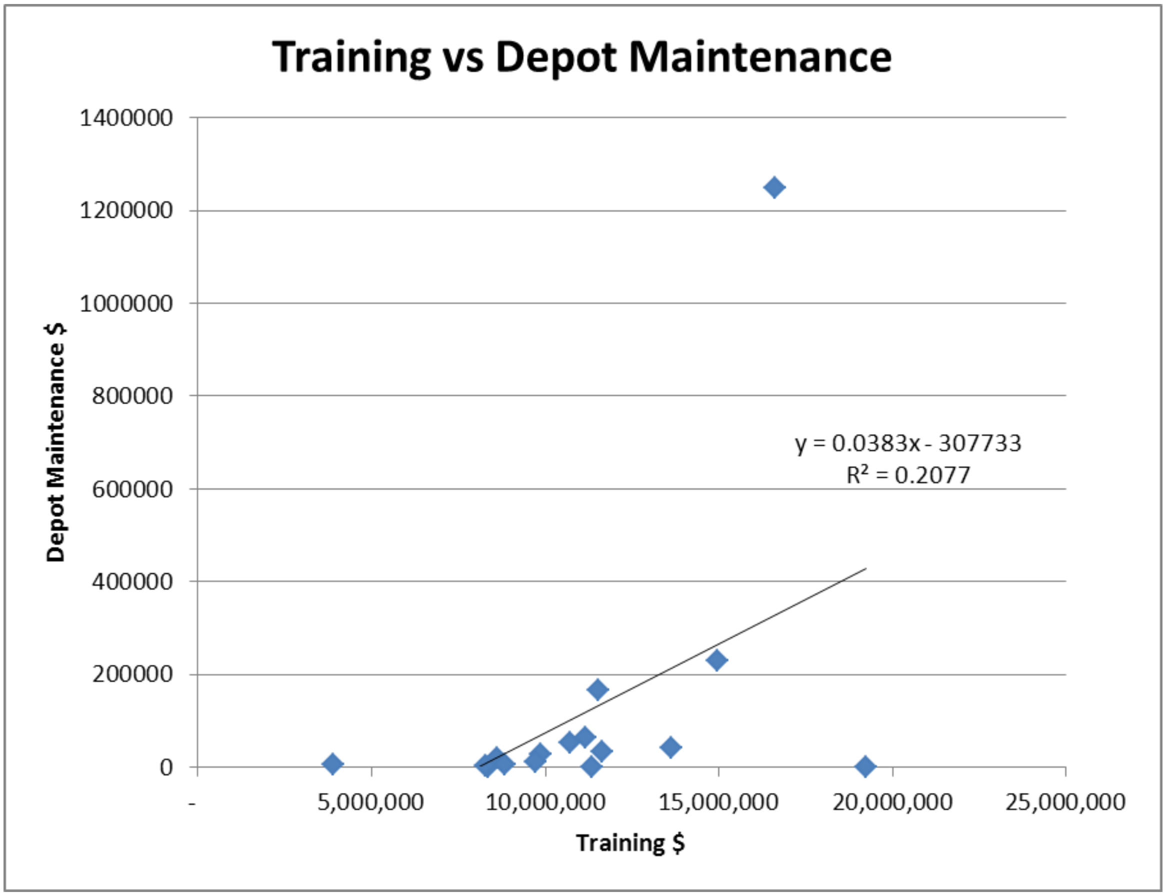


Figure 15. Training vs. Depot Maintenance Scatter Plot

Graphical analysis of several data categories indicated noticeable changes after the introduction of CBT. For example, Labor Ashore—Intermediate Maintenance Manhours showed significant change (Figure 16). The figure shows number of manhours spent on IM for selected ships from FYs 1995 through 2010. Beginning in FY04, the IM manhours increased significantly for the selected DDG-51 and CG-47 class ships. While this may be partially explained by changes to Navy maintenance policy described in Chapter III, it corroborates the evidence suggested in Figure 14, namely that as CBT is introduced and training costs decrease, intermediate maintenance hours and cost increase. This trend was not as evident, however, for the FFG-7 class. This may be explained by funding of the ship class, since many of these ships belong to the Naval Reserve Force and it is likely that their funding levels did not change throughout the period studied.

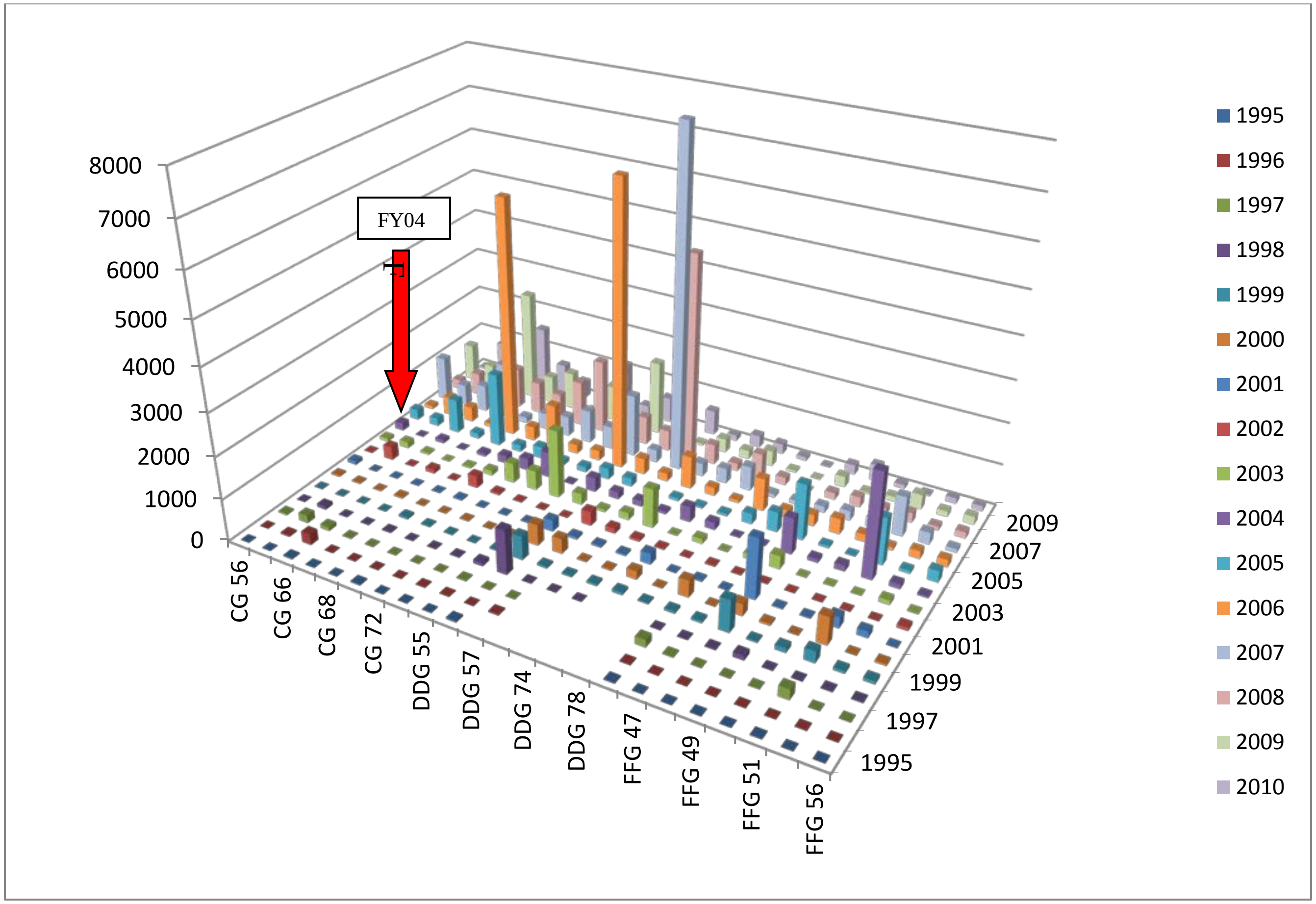


Figure 16. Labor Ashore - Intermediate Maintenance Manhours

### 3. Consolidated Data

The cleaned consolidated data were imported into Minitab® (a statistical software package) for analysis. Paired t-tests were conducted to determine whether the means of paired observations (selected ships pre- and post-CBT) were different. The null hypothesis states that the population means are equal while the alternative hypothesis states that the means are not equal. A p-value less than the stated level of significance, 0.05 in this case, indicates that the means are not equal and the null hypothesis can be rejected. A t-statistic less than 0.00 indicates that the first mean sampled is smaller than the second, while a positive t-statistic suggests the opposite. In this case, the response variables were tested to determine whether there was a significant difference between means pre- (mean 1) and post-CBT (mean 2). The null hypothesis is that there is no significant difference in the means before and after the introduction of CBT. The alternate hypothesis is that there is a significant difference between the means due to CBT. A negative t-statistic indicates that the pre-CBT mean was smaller, while a positive t-statistic indicates that the post-CBT mean was smaller. Response variables used in this study were: Organizational Parts Cost, Exchanges LOGCEN Cost, Manhours Organizational Labor, Training, NETPDTC, O&S Cost, O&S Cost less Training, O&S Cost less Training less Maintenance and Modernization, and O&S less Maintenance and Modernization (Table 8).

| Response Variable | Degrees of Freedom | T-statistic | p-value |
|---|---|---|---|
| Org. Parts Cost | 67 | -3.96 | 0.000 |
| Exchanges LOGCEN Cost | 47 | -8.69 | 0.000 |
| Manhours Org. Labor | 67 | -5.6 | 0.000 |
| Training NETPDTC | 67 | 27.06 | 0.000 |
| O&S Cost | 67 | 32.12 | 0.000 |
| O&S Cost - Training | 67 | 31.44 | 0.000 |
| O&S - Training - Maint. & Mod | 67 | 32.38 | 0.000 |
| O&S - Maint. & Mod. | 67 | 32.31 | 0.000 |

Table 8. Paired T-test results

In all cases, the p-values were less than the level of significance, indicating that the null hypothesis should be rejected and the alternate hypothesis should be accepted.

This means that there was a significant difference between the means pre- and post-CBT. The t-statistics show that the means for Organizational Parts Cost, Exchanges LOGCEN Cost, and Manhours Organizational Labor were higher after the introduction of CBT. Additionally, the mean costs for Training—NETPDTC, O&S Cost, O&S Cost less Training, O&S Costs less Maintenance and Modernization, and O&S Costs less Training less Maintenance and Modernization were lower after the introduction of CBT.

## B. SUMMARY

Manning for the STG rating did not have a significant impact on the results of this thesis study. The optimum manning initiative affected some ratings more than others. Based on the data presented, the STG rating did not see significant reductions. This does not mean, however, that workloads did not increase for the rating. The ship-wide manning reductions affect all rates because the workloads for in-port watches, special evolutions like underway replenishment, and inspection preparations are shared across all ship's personnel. There is no method available to quantify any additional workload STGs may have taken on as a result of optimum manning, but since manning levels did not change significantly, the burden may have been easier to bear for this rating as opposed to others.

The VAMOSC data provided revealed that training costs for the STG rating did decrease after the introduction of CBT. Additionally, the data showed that maintenance costs, particularly IM, increased over the same period. Single-factor regression analysis revealed no significant relationship between total training cost and the selected maintenance variables: Unit Level Consumption, Equipment Rework, Intermediate Maintenance, and Depot Level maintenance, however, examination of the scatter plot for IM provides some evidence to corroborate the finding that IM costs increased after CBT. Because the evidence was inconclusive, additional studies were used to further examine the cost data for selected response variables.

Paired t-tests were performed for the following selected response variables from the consolidated data table: Manhours Organizational Labor, Training—NETPDTC, Organizational Parts Cost, Exchanges LOGCEN Cost, O&S Cost, O&S Cost minus

Training, and O&S Cost minus Training minus Maintenance and Modernization. The p-values for all response variables were less than the level of significance, 0.05, indicating that there is a significant difference between the means of the selected variables due to CBT.

While some of the results clearly did not support the assumption that CBT would lead to higher O&S costs (in fact they indicated the opposite) there was evidence to indicate that the introduction of CBT led to higher costs in three of the response variables: Manhours Organizational Labor, Organizational Parts Cost and Exchanges LOGCEN Cost. All three categories relate to maintenance actions performed by sailors at the unit (ship) level. If the conversion to CBT were to have an effect anywhere in the Navy maintenance system, it would be at maintenance activities where sailors were performing maintenance, like afloat units and IM facilities. For this reason, rising IM costs noted in the VAMOSC data and scatter plots may also be attributed to the conversion to CBT; however, a confounding variable for IM is that several shore-based IM facilities were closed and shore-based IM billets for sailors were eliminated.

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# VIII. CONCLUSION AND AREAS FOR FUTURE RESEARCH

## A. CONCLUSION

In 2001, ERNT released its report, *Revolution in Training: Executive Review of Navy Training Final Report*. The results of the report were a major overhaul in the US Navy's training practices, including the replacement and supplementation of ILT with CBT in A and C schools. Fleet leadership reported that sailors entering the Fleet after receiving CBT training did not have the requisite KSATs to perform their assigned jobs. Extensive OJT, supervision, and assistance in performing basic maintenance tasks were required to bring CBT-trained sailors up to speed.

At the same time, the U.S. Navy reorganized its maintenance program and introduced the optimal manning concept to the Fleet. Total manning levels on ships decreased and other ship requirements did not change, meaning that ships had to do more work with fewer personnel. Many PMS requirements were extended or eliminated on ships with the expectation that shore facilities would pick up the slack, but shore facilities experienced manning reductions at the same time. This meant that less planned maintenance was being performed on equipment, resulting in increased opportunities for equipment failure and decreased Fleet material readiness.

The combination of changes in training, manning, and maintenance had negative effects on Fleet readiness, highlighted extensively in the Balisle report. This thesis examined three questions: 1) did the use of CBT in A and C schools result in sailors entering the fleet with lower levels of knowledge and skill sets than those sailors completing ILT? 2) did the transition to CBT result in cost savings in training? 3) from a systems perspective, if sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased operations and maintenance costs?

To answer the first question, government studies of the Navy's CBT training were examined, which confirmed that while the transition to CBT resulted in shorter training times, sailors reporting to the Fleet were not as well prepared as ILT-trained sailors of the past. To answer the second question, DON Budget Reports from FYs 2000 to 2012 were analyzed to understand changes in training costs during the periods before and after the implementation of CBT. The analysis reveals that overall training costs remained fairly flat and specialized skills training costs nearly doubled over the same period, which suggests that any cost savings were realized in areas other than training delivery in A and C schools.

To answer the final question, the thesis examined changes to training and maintenance costs from both a macro and micro perspective. At the macro level, analysis of DON O&M budgets for the periods before and after CBT implementation shows that Intermediate Maintenance budgets more than doubled and Depot Level Maintenance budgets nearly doubled during the period of interest. Unfortunately there were too many confounding variables that could have affected O&M costs during this period of time to draw any conclusions about the effect of training on maintenance costs. To control some of these variables it is necessary to examine the question at a micro level.

The thesis attempted to answer the last question by focusing on a single Navy system, the AN/SQQ-89(v) sonar system, to show if the results of the conversion to CBT are clearly connected to that system. Extensive data were collected on the 89 system to determine how the impact of changes in one area, training, impacted the system as a whole.

The results of the study revealed several pieces of useful information. Training costs for the 89 did decrease from FYs 2000 to 2010 during the conversion to CBT. Over the same time period, maintenance costs, particularly IM costs, also increased. Regression analysis further indicates that a decrease in training costs is related to an increase in IM costs, although the relationship was not strong. Finally, paired t-tests showed that the conversion to CBT may have led to cost increases in Manhours Organizational Labor, Organizational Parts Cost and Exchanges LOGCEN Cost, all associated with maintenance performed by sailors at the unit (ship) level. Rising IM costs and increases in unit level maintenance variables due to CBT can be attributed to the fact that the conversion to CBT training would be most noticeable at maintenance activities where sailors are performing the maintenance.

As the Navy IG, GAO, and Balisle reports suggest, there are several factors that have contributed to declines in Fleet readiness. Most notably, the simultaneous combination of changes in training, maintenance, and manning policies appear to have had lasting negative impacts, including rising Fleet maintenance costs. The data analysis performed in this thesis shows that the change to CBT was statistically significant when compared to Operating and Support Cost variables, but it is also likely that changes to all three areas (training, maintenance, and manning) had collective negative effects which go much further than rising maintenance costs.

The data collected and used in this analysis answered the thesis questions to a degree, but do not represent a complete answer. Unfortunately, answering these types of questions only with O&S cost data may be the only method available. Since there were no measures of effectiveness for training in place during the ILT era, a baseline cannot be established to compare effectiveness of ILT to CBT, and since there were no measures of effectiveness in place when CBT was introduced, it will be similarly untenable to measure the impact of any future changes from a training effectiveness standpoint. It is clear that policy changes in the 2000s impacted Fleet readiness in a negative manner, but no clear conclusions can be drawn about the impact of CBT on total system cost from the data examined in this study.

## B. AREAS FOR FUTURE RESEARCH

It may be useful to study the impacts of the conversion to CBT on other Navy systems. From a training perspective, the lack of measures of effectiveness for training may prove frustrating in drawing any conclusions, but from a cost perspective it may be possible to gain further insight into the types of cost most affected by CBT. A study comparing the maintenance effectiveness over time of sailors trained under ILT vs. sailors trained primarily through CBT would be most useful, but would require a significant effort and a thesis that develops a system for measuring training effectiveness in the Navy would be also be of great interest.

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# APPENDIX : OPERATING AND SUPPORT (O&S) COST

This appendix lists definitions for terms found in the data tables provided by Navy VAMOSC. All definitions were found in the VAMOSC *Ships User's Manual*.

**Engineering and Technical Services – Program Office** is the "cost of engineering and technical services provided to a ship other than during intermediate or depot availability. These services are provided by Navy engineering activities (Navy Engineering and Technical Services (NETS)) or by contractors (Contractor Engineering and Technical Services (CETS))." (IBM, 2011, p. 52)

**Equipment Re-work** includes the "cost of overhaul, rework, or repair of (1) major ordnance equipment including fire control equipment, gun mounts, torpedo tubes, other missile launchers, and other miscellaneous equipment." (IBM, 2011, p. 45)

**Labor – Afloat Intermediate Maintenance** is the "cost of labor expended by a tender, repair ship, or equivalent afloat Intermediate Maintenance Activity (IMA) for the repair and alteration of the indicated ship." (IBM, 2011, p. 30)

**Labor – Ashore Intermediate Maintenance** is the "Cost of labor expended by an ashore IMA for the repair and alteration of the indicated ship." (IBM, 2011, p. 30)

**Maintenance and Modernization – Depot** refers to "…reported costs associated with depot level maintenance performed for the ship by public shipyards, private shipyards, ship repair facilities (SRFs), and other organizations. Public-shipyard-reported costs come from the shipyard management information system (SYMIS), and represent fully burdened costs for those activities. Regional Maintenance Centers/Supervisor of Shipbuilding (RMCs/SUPSHIPs) -reported costs represent progress payments made by RMCs/SUPSHIPs to private shipyards, and are also fully burdened costs. Other cost elements are discussed below in their respective sections." (IBM, 2011, p. 31)

**Maintenance – Intermediate** is the "cost of material and labor expended by a tender, repair ship, or equivalent ashore or afloat intermediate maintenance activity in the repair and alteration of other vessels." (IBM, 2011, p. 29)

**Manhours – Intermediate Maintenance Afloat** is the "labor manhours performed by a tender, repair ship, or equivalent afloat IMA for the repair and alteration of the indicated ship." (IBM, 2011, p. 57)

**Manhours – Intermediate Maintenance Ashore** is the "labor manhours performed by an ashore IMA on the repair and alteration of the indicated ship." (IBM, 2011, p. 57)

**Manhours – Organizational Corrective Maintenance** is the "…manhours expended by the ships' force for the performance of reported organizational corrective maintenance. Ships report corrective maintenance in accordance with current Maintenance and Material Management (3-M) System guidelines." (IBM, 2011, p. 57)

**Material – Afloat Repair Parts Intermediate Maintenance** is the "cost of reported repair parts used by an afloat IMA in the repair and alteration of a ship and installed equipment." (IBM, 2011, p. 31)

**Material – Ashore Repair Parts Intermediate Maintenance** is the "Cost of reported repair parts used by an ashore IMA in the repair and alteration of a ship and installed equipment." (IBM, 2011, p. 31)

**Other – Depot** includes all other depot-level maintenance costs not otherwise covered. This includes all depot maintenance at public, private, and SRF shipyards.

**Repair Parts and Repairables** refer to "repairable and repair parts for use in maintenance of the ship and installed equipment." (IBM, 2011, p. 26)

**Training – NETPDTC** is the "cost of C, D, F, G, and T formal course training for the ship's crew, officer and enlisted, to enable them to perform assigned maintenance and operational tasks." (IBM, 2011, p. 51)

**Training – Program Office** is the "cost of program office-funded training for the ship's crew, officer and enlisted, to enable them to perform assigned maintenance and operational tasks." (IBM, 2011, p. 51)

**Unit Level Consumption** is the "cost of all materials used or consumed by the ship with the exception of materials utilized in the intermediate and depot level maintenance effort." (IBM, 2011, p. 24)

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# LIST OF REFERENCES


*AN/SQS-56 Sonar*. (n.d.). Retrieved May 7, 2012, from Harpoon Headquarters: http://www.harpoondatabases.com/encyclopedia/Entry2306.aspx

*Analysis of Variance*. (n.d.). Retrieved May 9, 2012, from The Measurement Group: http://www.themeasurementgroup.com/definitions/analysis_of_variance.htm

Balisle, P. M. (2010). *Fleet Review Panel of Surface Force Readiness.*

Bassi, L., Gallager, A., & Schroer, E. (1996). *The ASTD Training Data Book.* American Society for Training and Development.

Bowling, C., & McPherson, R. (2009). *White Paper: Shaping the Navy's Future.*

Chapman, B. (2006). *PowerPoint to E-Learning Development Tools: A Comparitive Analysis of 20 Leading Systems.* Sunnyvale: Brandon Hall Research.

Chapman, B. (2007). *LCMS Knowledgebase 2007: A Comparison of 30+ Enterprise Learning Content Management Systems.* Sunnyvale: Brandon Hall Research.

Chatham, R., & Braddock, J. (2000). *Traning Superiority & Training Surprise.* Defense Science Board Task Force.

Department of the Navy. (2011). *FY 2012 Budget.*

Department of Defense. (2004). *Development and Management of Interactive Courseware (ICW) for Military Training.*

Department of Defense. (2009). *Military Training - DoD Directive 1322.18.*

Department of Defense. (2011). *DOD Financial Management Regulation 7000.14-R.*

Department of Defense Inspector General. (2004). *Human Capital: Management of Navy Senior Enlisted Personnel Assignments in Support of Operation Iraqi Freedom.*

Department of the Navy. (1999). *Fiscal Year (FY) 2000/2001 Biennial Budget Estimates: Justification of Estimates, Operation and Maintenance, Navy.*

Department of the Navy. (2000). *Fiscal Year (FY) 2001 Budget Estimates: Justification of Estimates, Operations and Maintenance, Nave.*

Department of the Navy. (2001). *Fiscal Year (FY) 2002 Amended Budget Submission: Justification of Estimates, Operations and Maintenance, Navy.*

Department of the Navy. (2002). *Fiscal Year (FY) 2003 Budget Estimates: Justification of Estimates, Operations and Maintenance, Navy.*

Department of the Navy. (2003). *Fiscal Year (FY) 2004/2005 Biennial Budget Estimates: Justification of Estimates, Operations and Maintenance, Navy.*

Department of the Navy. (2003). *Manpower Determination Methodology (The Process) for Ships, Submarines, and Afloat Staffs.*

Department of the Navy. (2004). *Fiscal Year (FY) 2005 Budget Estimates: Justification of Estimates, Operations and Maintenance, Navy.*

Department of the Navy. (2005). *FY 2006/2007 Budget.*

Department of the Navy. (2006). *FY 2007 Budget.*

Department of the Navy. (2007). *FY 2008 Budget.*

Department of the Navy. (2008). *FY 2009 Budget.*

Department of the Navy. (2010). *FY 2011 Budget.*

Department of the Navy. (2010). *Total Ownership Cost (TOC) Guidebook.*

Department of the Nsvy. (2009). *FY 2010 Budget.*

Dhanjal, R., & Calis, G. (1999). Computer Based Training in the Steel Industry. *Steel Times Vol. 227 No. 4*, 130-131.

Executive Review of Navy Training (ERNT). (2001). *Revolution in Training - Final Report.*

Government Accountability Office. (2010). *Military Readiness: Navy Needs to Reassess Its Metrics and Assumptions for Ship Crewing Requirements and Training.* Washington, D.C.

Government Accountability Office. (2011). *Military Readiness: Navy's Report to Congress on the Impact of Training and Crew Size on Surface Force Material Readiness.* Washington, D.C.

IBM. (2011). Naval Visibility and Management of Operating and Support Costs (VAMOSC) 10.3, Ships, User Manual.

IBM. (2011). Naval Visibility and Management of Operating and Support Costs (VAMOSC) 11.0, Detailed Ships, User Manual.

Jane's Information Group. (2010, December 6). *Jane's Underwater Warfare Systems: AN/SQQ-89(v).* Retrieved January 30, 2012, from Jane's Web Site.

Jones, A. (2009, September 25). *Surface Warfare Indoctrination Academy: Providing Training, Building on Tradition.* Retrieved May 3, 2012, from Japan Bases: http://www.japanbases.com/forums/aft/902.aspx

Lieb, S. (1991). *Principles of Adult Learning.*

Louden, J. J. (n.d.). Total Ownership Cost. Naval Sea Systems Command (NAVSEA).

MacKay, A. (2007). *Motivation, Ability, and Confidence Building in People.* Butterworth-Heinemann.

Naval Inspector General. (2009). *Computer Based Training.*

Naval Personnel Development Command. (2002). Navigating the Sea of Learning - The Navy's Revolution in Training Update.

Naval Sea Systems Command (NAVSEA). (1998). *AN/SQQ-89(v) ASW Combat System: System Configuration Summary by Variant for ASW System Integration.* Washington, D.C.: NAVSEA.

Naval Sea Systems Command. (2003). *NAVSEAINST 4790.3B Ship's Maintenance and Material Management (3-M) Manual.*

Navy Personnel Command. (2012, April). *NEOCS Manual Vol. II.* Retrieved May 2, 2012, from Navy Personnel Command Web Site: http://www.public.navy.mil/bupers-npc/reference/nec/NECOSVolII/Documents/Chap-4.pdf

Orlansky, J., & String, J. (1979). *Cost-Effectiveness of Computer-Based Instruction in Military Training.* Institute for Defense Analyses, Science and Technology Division.

*United States Navy Fact File.* (n.d.). Retrieved May 7, 2012, from United States Navy Web Site: http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=318&ct=2

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